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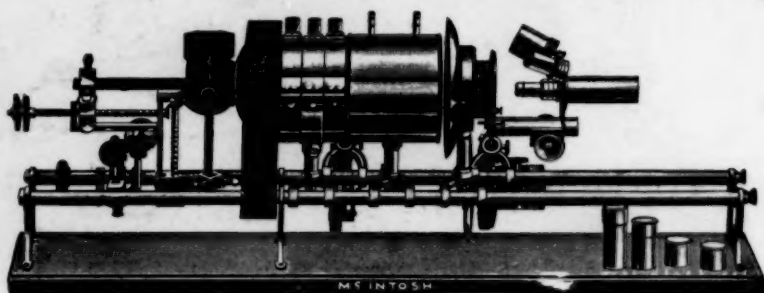
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SCHOOL SCIENCE AND MATHEMATICS

VOL. XVII, No. 3

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WHOLE No. 140

INHERITANCE AND RESPONSE¹.

BY JOHN M. COULTER,
University of Chicago.

I am to deal with some fundamental phases of biology which are to the front just now, and which teachers of biology should realize. They have not invaded our textbooks seriously as yet, but they are somewhat revolutionary. Such illustrations as I shall need to use are naturally taken from my own field, but they are duplicated in our experience with animals; so that although the illustrations may be botanical, the principles involved are biological.

The modern history of botany is a series of segregations of subjects. Each new segregate has attracted a certain number of recruits from the older subjects. There have always been two categories of botanists: those who move on promptly to the newer phases of their subject, and the old guard that never moves on. The latest segregate of the series is plant genetics, which is making so large an appeal to botanists that if the epidemic continues all botanists are in danger of becoming geneticists. What I wish to present has a bearing upon the work of this important modern field of botanical activity. In this presentation, however, I shall not introduce the details of material. These details are too numerous for the time at command, and too technical for any audience excepting one of professional geneticists.

Plant geneticists have begun, just as did plant morphologists, by using the most complex material. So long as plant morphologists focused their attention upon seed plants, they were accumulating data that could be interpreted only empirically. When they included a study of the lower forms, the simpler groups became keys to the more complex ones, and interpreta-

¹ Read before the Biology Section of the Central Association of Science and Mathematics Teachers, at the University of Chicago, December 1, 1916.

tion became scientific. In plant genetics we are still mainly in the stage of complex material. Sexual reproduction is selected as the method of reproduction to be investigated, and the particular sexual structures selected are so peculiarly involved with other structures that it is impossible to analyze the factors involved in the results. Not only are the sexual structures beyond the reach of observation and of experimental control, but there is an alternation of two forms of reproduction, inheritance being carried through one generation to express itself in the next.

Furthermore, the origin of embryos produced in seeds is not assured. While we may assume that for the most part they are the result of fertilization, which in its gross aspects can be controlled, the increasing number of cases of parthenogenesis, vegetative apogamy, and sporophytic budding introduces a serious element of uncertainty. The program between pollination and fertilization, and between fertilization and the escape of the embryo from the seed, is a very long one, and not a single stage of it is under observation, much less under control. In other words, we are working empirically upon our problem as yet.

Everyone is interested more or less in the problem of inheritance, and a vast amount of literature is developing, ranging from the records of scientific experiments to the unscientific phases of eugenics.

When men began to think of inheritance as possibly having a scientific basis, they hit upon the obvious effects of environment upon structures. Plants and animals were then conceived of as plastic organisms molded by their environment. In other words, we are what we are because of our surroundings. This was a natural first view, based upon the observation of superficial phenomena.

Later, the internal structures of plants and animals came under observation, and a wonderful mechanism was discovered which seemed adequate to account for the facts of inheritance. We could see the actual material that guides inheritance from generation to generation. As a result, inheritance came to be looked upon as an inevitable fate, bound up with a machine that grinds out the same product, no matter what the environment may be. In other words, it was the theological doctrine of foreordination applied to inheritance.

Then experimental work in the breeding of plants began,

and data began to multiply which indicated that the hereditary machine does not always turn out an identical product, but that variation is constant and in every direction. Especially was this assumed to be true in the case of sexual reproduction, in which two individuals of different ancestry combine in the product. This was purely an assumption, as it turns out. No similar experimental work had been done with spores, which produce more new individuals among plants than do eggs; but it was assumed that the product of spores must be invariable. In fact, it is a common statement that the significance of sex in the plant kingdom is to introduce variation and therefore a chance for evolution. Recent experimental work has shown that inheritance by spores is just as variable as inheritance by the sex method. However, this is just beginning to be realized and has not penetrated the camp of geneticists very far.

Then came the explanation of the variable product observed in sex inheritance. The machine had been constructed in such a rigid way that an expansion of variations presented difficulties. These difficulties were met by terminology; and if genetics had done nothing else, it would be remembered for having greatly enriched our vocabulary. All sorts of mimic combats were imagined as occurring within a fertilized egg; names were given to the victors and the defeated, but the result was never in doubt, for it could be stated with precision in a mathematical formula. If an unexpected result appeared, it was easy to explain it by reconstructing the formula.

All the time there was lurking in the background spore reproduction, with fully as variable results, but with no mimic combats or formulas to explain them.

Finally, it began to be discovered that the machine was subject to change; that it could be changed experimentally; and that it responded to varying conditions. A machine that is a variable has lost the rigidity of a machine, and cannot determine an invariable result. And so we have begun to swing back to environment as a factor in the result. It is environment, however, with a new definition. It may be the old-fashioned environment, entirely external to the plant or animal; or it may be the internal conditions in which a living cell is working. In either case, the living substance *responds*, and the result is recorded in the product. As a consequence, we have come to recognize that two factors determine the product of reproduction, namely, inheritance and response. They are easily defined.

Response includes those results whose cause has been discovered; while inheritance includes those results whose cause has not been discovered, as yet. It is needless to say that the territory covered by response is increasing as experimental work progresses; and that the territory covered by inheritance is correspondingly diminishing.

When variations occur, it has always been a question whether they are inheritable or not. This has become the fundamental distinction between what are called fluctuating variations and mutations. Recent experiments with certain lower plants, which reproduce by spores, have shown that if the conditions which induce the variation remain constant, the variation is inheritable. Any response, therefore, becomes inheritable if the conditions are static. In other words, what we call inheritance is simply a record of static conditions; and since in nature the succession of conditions is fairly uniform, it is no wonder that the results are fairly uniform, and seem to be ground out by a rigid machine.

It is generally assumed that there are certain unchangeable features in every plant and animal which may always come under the category of inheritance. This is probably true; at least we have no other way of explaining why the egg of a sunflower, for example, even with the wildest change of conditions, can produce nothing but a sunflower. It may be made to produce a new kind of sunflower, but the fundamental sunflower structure is there. So we are content at present to recognize inheritance and response as two factors in reproduction, the one dealing with fundamental structure and the other with its variations. The real question today is: What are the limits of response and at what point does it encounter the dead wall of inheritance?

Of course there is a terminology applied to inheritance as here defined. Terminology is always ready to explain what baffles knowledge. The explanation is that inheritance involves the essential organization of the germ plasm. But what is the organization of the germ plasm, essential or unessential? This definition simply introduces us to an unknown factor. We shall have to know the factor before we can discover whether it can be controlled or not.

I wish now to give a few illustrations of responses; and you may determine for yourselves whether they are superficial responses, such as all will allow, or somewhat fundamental.

In the days of rigid morphology, a plant was supposed to go through a definite routine during its life. For example, certain of the algae live vigorously for a time, then produce spores, finally produce sexual cells, and then die. It was natural to infer that the production of spores and the production of sexual cells belong to definite periods in the life of the plant, periods fixed in the definite program of the life history. Now it is known that these three stages of the plant (vegetative activity, spore production, sexual cell production) do not represent definite periods, fixed like the orbit of a planet, but are responses to three different conditions. Any one of these responses can be secured at any period in the history of the plant, and in any order. If the conditions favor maximum vegetative activity, neither spores nor sexual cells are produced; if the conditions for vegetative activity become less favorable, spores are produced; if the conditions become still less favorable, in fact quite unfavorable for vegetative activity, sexual cells are produced. In this case, also, any cell may be made to do any of these things. Here are a lot of fundamental responses that loosen up our former rigid morphology and suggest that perhaps all structures may arise as responses rather than as inevitable, foreordained results, no matter what the conditions may be.

To carry this same situation further, I wish to report a result obtained in connection with experiments upon certain algae. One of the much-stressed distinctions among certain groups of algae has to do with the behavior of the fertilized egg in germination. In some cases an egg produces a new plant directly; in other cases it produces spores, which in turn produce new plants. To the morphologist this has seemed quite a fundamental condition. The experiments referred to undertook to apply to these eggs what had been discovered in reference to vegetative activity and spore production. Eggs which were known to produce only spores were placed in conditions favorable to maximum vegetative activity, and instead of producing spores they produced new individuals directly. Also, eggs which were known to produce only new individuals directly were placed in conditions less favorable to vegetative activity, and instead of producing new individuals they produced spores. In neither case had these eggs been known to behave this way in nature; but it was needed only to change the conditions of germination to change the result. This does not suggest the work of a machine, but a response to conditions that result in different reactions.

I wish to use as my second illustration some observed conditions of cotyledon formation. You recall the two great groups of angiosperms, dicotyledons and monocotyledons, the former having two cotyledons and the latter one. This distinction is regarded as so fundamental that, when other features fail to distinguish the two groups, this cotyledon feature is appealed to as the court of last resort. In tracing the development of embryos, we found that at least two cotyledons always start, but that in monocotyledons one of them does little more than start and the other one finally appears as the only cotyledon. This naturally suggests the question: What checks one of the cotyledons in monocotyledons? The only difference in the conditions for development that we could observe in the two cases was that in monocotyledons the first leaves emerging between the two cotyledons begin a vigorous development about as soon as the cotyledons start. This suggested the possibility that one of the cotyledons might be crowded out by the cluster of precocious leaves.

This suggestion was emphasized by the fact that in dicotyledons the first leaves are relatively late in appearing, and do not grow at all until both cotyledons are fully formed.

We now find in traversing a considerable range of monocotyledons that in some of them the first leaves are not quite so precocious as usual, and in consequence both cotyledons develop. Sometimes they are unequal, but in an increasing number of cases the embryo is quite normally dicotyledonous. In other words, one can transform a monocotyledon into a dicotyledon, so far as the embryo is concerned, by checking the development of the first leaves.

There is no need to multiply illustrations. The two I have used are selected from many, all of which indicate that the field of response is widening, and that it is beginning to include some of the characters which we have regarded as fundamental and therefore inevitable.

In conclusion, I wish to indicate a field of experimental work which bids fair to uncover some of the fundamental facts in reference to inheritance and response.

If sexual reproduction must be studied, it would seem desirable to use material selected from the more primitive sexual forms, material in which the sexual structures are not so involved with other structures, in which the whole performance of fertilization and embryo development is in sight and capable of control.

The difference between a sex act and an embryo development under cover, and in the open, when experimental control is the end in view, is too obvious to need further explanation.

Furthermore, in these simpler sexual forms the origin of sex is observable, so far as it is represented by the sexual cells, and the general conditions of origin are known, conditions which are sadly in need of analysis in experimental work. It must be evident that a knowledge of the factors involved in the origin of sex may throw some light on the function of sex in general. But the origin of sex involves a still more fundamental problem.

Sexual cells are related to spores; that is, spores are historically intermediates between vegetative cells and sexual cells. This suggests that the origin of spores and inheritance through them deserve attention as a preliminary to the origin of sexual cells and inheritance through them. In other words, there are certain things that all forms of reproduction have in common, and these should be kept distinct from the things which are peculiar to sexual inheritance.

The plant geneticist may not be interested in the conditions that result in sexual cell formation, and even less interested in the conditions that result in spore formation, but these are fundamental to the problem of reproduction, and therefore fundamental to the problem of inheritance. A practical plant breeder may be interested only in the fact that he can obtain a new individual from a seed, the pedigree of whose embryo in the nature of things cannot be demonstrated, but only inferred; but a scientific plant breeder, whom we now call a geneticist, must be interested in the conditions that determine inheritance, and these include the conditions that determine reproduction in general.

No more favorable material for determining the fundamental facts of inheritance can be found among plants than spores of the simpler forms. They are accessible, and therefore capable of control; a succession of spore-produced individuals represents a line whose purity cannot be questioned; the so called "modification of the germ plasm" can be accomplished with a precision that is impossible in an ovary and ovule-enclosed egg, to say nothing of the sperm. In short, freed from all entanglements of sex, the possibilities of variation in pure lines can be determined, and the possibilities of the inheritance of such variations. Such work will establish the facts common to all inheritance, and will enable us to recognize the contribution of sex to inheritance.

This work demands not merely the technique of plant breeding, but it involves also the technique of cytology to discover the structural changes; and the technique of physics and of physiological chemistry to determine the conditions and substances that are factors in the various processes. Perhaps of largest significance is the fact that, just as the doctrine of evolution broke up a static taxonomy, so this experimental work with inheritance is breaking up a static morphology, and a static genetics, encrusted with rigid definitions, and is making these great fields dynamic.

Those who wish to project the facts of inheritance and response into the field of eugenics may find some fertile suggestions to consider. If these two factors are involved in every result of reproduction what is the contribution of each? Is the control of inheritance the only problem of eugenics? Our present picture of reproduction is something as follows. A fertilized egg includes a wide range of possibilities. Inheritance determines the number and nature of these possibilities; for our possibilities are limited by those we have received. No one of us ever develops a tithe of his possibilities; in other words, our stock in trade is always much larger than we use. The parental selection of possibilities may be no clue to our own; that is, we are not necessarily doomed by the selection our parents have made, for they pass on to us possibilities they have never called upon.

If inheritance limits us only in the number and nature of our possibilities, what determines the selection? Here is where the role of response appears and the response follows what may be called *opportunity*. The conclusion is, that while we must see to it that inheritance is as favorable as possible, it is even more important to see to it that every child shall have a *stimulating opportunity*.

THE JUNEAU GOLD BELT.

The large mining developments near Juneau, Alaska, have attracted attention to the northern extension of the Juneau gold belt. Though relatively little productive mining has yet been done in that area, some developments are under way. The region is heavily timbered and therefore difficult to prospect. In spite of the difficulties detailed topographic and geologic maps of this region have been made. The maps are published, together with a description of the geology and mineral resources, in a report entitled *The Eagle River Region, Southeastern Alaska*, by Adolph Knopf (*Bulletin* 502), which may be procured on application to the Director of the United States Geological Survey, Department of the Interior, Washington.

WHERE ARE WE IN CHEMISTRY?

BY WILLIAM H. WILEY,

State High School Inspector, Columbus, Ohio.

In order to determine the present status of chemistry teaching in the American high schools, a questionnaire was sent to about three hundred high schools in cities of over five thousand population. Seventy-two replies to the questionnaire were received. These returns were not confined to any particular section of the United States, although many came from the central states. About thirty states are represented. Of these, Illinois, Indiana, New York, New Jersey and Iowa total the largest number of individual returns. While the larger number of replies came from the average-sized high school, some of the larger cities, such as New York, Chicago, St. Louis, Seattle, and Newark, also responded to the request. The conditions of teaching and the conclusions we might draw from these replies will therefore be more or less typical of the chemistry work in the American high schools.

This questionnaire was confined largely to the various phases of chemistry teaching, the method, the materials taught, the aim in teaching and the pupils' attitude toward the work. It was also intended by these questions to determine the opinion of teachers as to the present needs and changes in high school chemistry. Teachers were asked to express themselves very freely on any of the topics, and while a few contributed something of value, the majority of teachers took pains to answer the questions as concisely and hastily as possible. The apathy to educational research, so apparent here, seems to be quite general among American school-teachers, and forms a decided contrast to the interest in problems of education as shown in other countries.

Tabulation shows that the high school registration varies from seventy to three thousand, and the chemistry class registration from five to three hundred. While the numbers registered in chemistry depend somewhat upon the registration of the high school, there is a wide divergence from any norm which we might establish. The chemistry registration depends upon other factors than registration of the school. The percentage of pupils in each school studying chemistry varies from 1.4 per cent to 20.9 per cent with an average of 11.78 per cent.

This average, however, is of little value as a norm. For example, the Barringer High School of Newark, N. J., records

9.9 per cent; the Norwich, Conn., High School records 3.16 per cent; the Waltham, Mass., High School records 20 per cent; and the Seattle, Wash., High School records 5.3 per cent. The size of the school has therefore little to do with determining the size of the chemistry class. The total registration of the seventy-two high schools is 49,442, and the total registration of the chemistry classes in these schools is 4,197, giving a total average of 11.78 per cent of the pupils studying chemistry. Since we have considered only schools which teach chemistry, it is very probable that the average of all high school pupils studying chemistry is not much above 6 per cent, or as the U. S. Commissioner report shows, about 6.7 per cent in 1910.

In regard to the sex of the chemistry teacher, we find that men far outnumber the women. In these seventy-two schools, there are sixty-three men and nine women, or 87.5 per cent men and 12.5 per cent women. Because of the manual side of chemistry teaching, it probably does not appeal to women, and also because schools give men the preference in this line, we find a majority of men.

The years of experience for each teacher extend from no experience to twenty-five years. It appears that the majority of teachers have had but three to five years of experience, and those having more than six years are connected with the large city schools. In the small school, the teacher is a temporary quantity and sooner or later migrates to the large city school, takes up a different profession, or becomes the school superintendent.

Summary of Questions Asked.

I. What is your aim, or what do you wish to accomplish?

The aims as stated may be classed under five heads, as follows:

1. The Practical or Vocational Aim. Expressed in various ways:

- "To discuss practical things scientifically."
- "Practical applications of chemistry."
- "To give essentials and practical applications."
- "To interest the student in applied chemistry."
- "To understand phenomena of daily life."
- "Knowledge of everyday things."
- "To put in the foundation for industrial and agricultural chemistry."
- "To prepare for domestic science."

2. The College Preparation Aim:

- "To prepare for college."
- "To prepare for college with as much commercial chemistry as is possible."
- "To prepare for college entrance requirements."
- "To prepare for the university."
- "To prepare for the regents' examinations."

3. *The Knowledge or Information Aim:*

"To give as thorough and as practical knowledge as possible."

"A general knowledge and liking for chemistry."

"To think and, incidentally, to acquire some facts."

"To acquaint the students with laws and forces of the earth."

"To establish fundamental principles."

"A knowledge of general chemistry."

"To give pupils a concise and clear view of principles."

4. *The Scientific Training Aim:*

"To lay a scientific basis for further study."

"Businesslike way of attacking problems."

"Power to observe closely and draw accurate conclusions."

"To fit the pupil for scientific investigation."

"To develop the experimental attitude—to observe phenomena."

"To discover things systematically for themselves."

"To seek the 'how' and 'why' of everything."

5. *The Moral Aim:*

"To inspire self-reliance and independence."

"To give the students a different outlook on things."

These five aims often overlap, a teacher often including two or possibly three of the aims in his statement. To give some idea of the dominating aim at present in chemistry, we have tabulated the number of times each aim is stated.

Practical aim	20
Scientific training	20
Information	13
College preparation	10
Moral aim	3

This shows that chemistry at present is dominated by two aims, a scientific training, and a practical interpretation of modern life. It appears that few teachers realize that the teaching of chemistry might be made the basis of moral training. Likewise, it shows that the college domination is not as powerful as is commonly thought. While it may be admitted that most chemistry teachers are required to prepare pupils for college, most teachers do not feel that chemistry in the high school exists primarily for college preparation. While ten teachers expressed the aim as preparatory for college, in each case the teacher expanded it to include other aims. The general feeling seems to be that chemistry is a vitally practical subject, the training in which gives the pupil a better interpretation of his environment and, at the same time, prepares him to meet his problems in a more scientific manner.

II. Which do you regard as more important—the actual facts imparted, or the training in scientific procedure? Why?

To this question there were sixty-eight replies.

Facts more important.....	9
Training more important	46
Both of equal value.....	13

This shows that American teachers believe that there is something in the training received from science which carries over into other problems of life. This is of interest since the transfer of training is largely a question of debate, and the indications are that habits are not transferable except to a slight extent, then only in so far as either the procedures are alike, or the habits are raised to the plane of the ideal.¹ While some of the leaders in school chemistry are advocating the value of facts imparted, it would seem that the majority of teachers accept the English point of view, and put faith in the value of training.

This is shown in the second part of the question when the teacher was asked to give his reason for so believing. A number of teachers said: Procedure is more important because:

- "Facts are soon forgotten" (ten teachers).
- "Gives power and habits of mind unlike facts."
- "Gives basis for orderly study in other lines."
- "Gives a method of attack for future problems."
- "It follows life in all its activities."
- "Habit of thinking scientifically—fits for life."
- "Time is too short to give facts."
- "Because it is of universal application."
- "More frequently applied to life."
- "The pupil must be taught to think."
- "Because it will carry over."
- "It fits the pupil to solve many problems in life."
- "It can be applied to any field of experience."

There is no doubt in these replies that teachers believe that training will apply in any field. Those who advocate the value of facts defend their statement in the following terms:

- "They need a foundation in the subject."
- "Because most students do not become chemists."
- "Scientific training is too limited."
- "To form a basis for later work—to be useful in daily life."
- "Few go further than the high school and facts seem better."
- "Theories and methods change, but facts are permanent."
- "That they may know the chemistry of life, health and general welfare."

III. *In what year do you give chemistry? Required or elective?*

To this question there were seventy-one replies, divided as follows:

In the fourth year.....	27
In the third year.....	27
Either third or fourth.....	14
Either second or third.....	1
Either second or fourth.....	1

This shows that chemistry is equally divided between the third and fourth year of the high school, and there is no indica-

¹ S. S. Colvin, *The Teaching Process*, pages 211-228.

tion of it gravitating toward either third or fourth. Prof. Elliott R. Downing in a recent study of high school science claimed that "Chemistry is evidently settling into the third year and physics into the fourth." The N. E. A. in 1899 recommended that chemistry be given in the fourth year, and this was sanctioned by the New York State Syllabus in 1900. In spite of these various influences, it would appear that chemistry has not as yet decided between the third and fourth years, but that it should be given in one or the other, and not earlier, is practically settled.

In reply to the second part, is it required or elective, we find that for the most part chemistry is an elective. Here are the facts:

Required	5
Elective	54
Required in scientific course.....	12

In spite of the facts that chemistry is regarded as an important subject, it is not made compulsory like English, algebra, Latin or history. Only five of the seventy-two schools require chemistry in any year. Twelve schools require it only in the courses preparing for technical colleges, or for domestic science.

IV. *How many hours (sixty minutes) are given to chemistry?*

V. *How many hours (sixty minutes) are given to laboratory?*

As to the time spent on chemistry, there is absolutely no agreement, not even in the same state. For example, in Berkeley, Cal., three hours are devoted to class and four hours to laboratory work, while in Long Beach, Cal., two hours are spent in class and three hours in the laboratory. In Brooklyn, N. Y., 3.75 hours are spent in class and only one hour in the laboratory, while in Little Falls, N. Y., 2.25 hours are spent in the class recitation and three hours in the laboratory. The total amount of time spent on chemistry in the seventy-one schools varies from three to 7.5 hours a week; the time spent in class recitation varies from one hour to 4.5 hours a week; and the time in individual laboratory work and class work, some divided equally, some divided it into one-fourth and three-fourths, others into one-third and two-thirds and various other combinations. The average time in hours per week spent on class instruction is 2.54 hours, the time spent in laboratory is 2.69 hours, thereby giving a total average of 5.24 hours per week in the seventy-one schools. The N. E. A. recommended 4.5 hours a week (six 45-minute periods) and the Regents Bulletin No. 7 of New York state advocated 5.25 hours (seven 45-minute periods).

VI. *Do boys and girls have the same work?*

Some of the schools were for boys or girls only, so that about six schools could make no reply. Sixty-seven replied.

Boys and girls have the same work.....	52
Girls have household chemistry.....	15

Aside from the household chemistry given for girls, there is no mention made of any other specialization, either for boys or girls, except in the high school at Waltham, Mass., where an advanced technical course is offered in addition to the general course. Specialization amounts to little more than a part of the general course. For example, some schools probably emphasize the agricultural phase, while others emphasize the industrial. The high school at Ft. Smith, Ark., gives a course recognized as first-year college chemistry. The students are taught analysis, and the school analyzes products for the local industries.

VII. *Do pupils enjoy chemistry? What are the reasons?*

Result:

Yes	66
No	0
Some	6

Practically all agree that students like chemistry. There is no definite statement to the contrary. Six teachers could not say yes unreservedly, and yet could not say no. Some of the expressions used were:

- "They like the laboratory work."
- "Those that like to think do."
- "They like it sometimes."
- "According to their natural inclinations."

The second part of the question is very interesting. The teachers were asked to state why pupils like chemistry. All sorts of reasons were given. Some said because of the spectacular and novel; others because pupils liked to work out problems for themselves; because they like to get away from books; they like the "doing side;" it appeals to them as real and concrete; and, in some cases, because they can see a money value in it.

Here are a few of the reasons quoted:

- "The spectacular in laboratory exercises. Practical relations."
- "They enjoy the practical applications."
- "They get to work out things for themselves which appeal to them."
- "They like to work with their hands and later welcome the accuracy which the work gives."
- "Enjoy work with hands, interesting daily phenomena, and excursions to factories."
- "Manual work. New facts learned by practice."
- "It is new and wonderful" (reply of three teachers).
- "They like experiments" (reply of seven teachers).

- "They enjoy working with their hands and seeing things happen."
 "Novelty attracts some while the application attracts others."
 "Natural curiosity which makes him discover by experiment."
 "Something doing all the time."
 "They realize these changes occur about us daily."
 "Because it is so practical."
 "The most information received and the novelty of the laboratory work."
 "Most pupils like to do things and get results."

VIII. *What Textbook do you use?*

Ten different textbooks are mentioned, and in two cases a departmental library is used. The results are as follows:

Brownlee and others	26	Alex. Smith	2
McPherson & Henderson	13	Bradbury's (Inductive)	2
Newell	11	Remsen	2
Hessler-Smith	8	Kaldenberg and Hart (Agr.)....	1
Morgan and Lyman	5	Blanchard and Wade	1
Departmental Library		2	

The three textbooks used most widely, as is shown above, are those of a descriptive nature. A. Smith classifies texts into two classes—those emphasizing mathematics at the outset and those which postpone it until later. From the text most generally used, it would appear that American teachers favored beginning mathematics early. Our study shows that the text is generally in agreement with the principles of method and the content of the course as expressed elsewhere. The teacher often finds, no doubt, that the greatest difficulty with most texts is the lack of correlation between the text and the experience of the pupil. Books are improving, however, as we know more about the adolescent mind.

IX. *Is the course based on the text or the laboratory?*

The results here indicate that the opinion is about equally divided: Text, twenty-four; laboratory, twenty; both, 25. While no reasons were asked, it may be fair to say that teachers of little experience stick pretty close to a textbook, while experienced teachers are apt to get away from the text, and base the work on the laboratory practice. This is a more difficult procedure and demands continual watchfulness on the part of the teacher. The next question points this out more clearly.

X. *In teaching a new topic, do you present it first in class or in the laboratory? Why?*

Present it first in class	38
Present it first in laboratory	28
This varies with the topic	5

The second part of the question asked why, and here are some of the reasons as given:

1. In the laboratory:

"To familiarize the student with the substances used."

"To give foundation and concrete conception of the work."

"To try to develop initiative."

"I have assumed that interest would be keener when results to be gotten were unknown."

"I believe this the place for the inductive method."

"It gives a much more definite understanding of the work."

"Let them acquire knowledge at first-hand where possible."

"To obtain facts for interpretation and to stimulate interest."

"As a basis for work and to avoid memory work."

"Better understanding and more readily remembered."

"They must get first-hand experience from nature."

"It is easier."

2. In class first:

"Because they get more from the laboratory when they know what to look for."

"They should have some idea of what to expect in experiment."

"Better attention."

"They are less liable to bungle the laboratory work."

"Easier" (2).

"Knowledge before action."

"High school pupils are not investigators."

"It is better for the beginner to know what to do and to expect."

"Because I do not think beginners have the ability to pick out things for themselves."

"Laboratory is a good fixing agent" (2).

"It saves confusion in large classes."

"Can better reach all the members of a class."

"To familiarize them with the subject and to give some idea of what to look for."

"Children of high school age are too helpless unless it is developed first in class."

We find here as in other parts of the report no agreement of opinion. There are some who believe in the inductive method, while others believe it has no place in the school. There are some who believe the results are better if taught in class first, while others believe that laboratory first produces better results.

XI. *Of the following methods, which do you consider most valuable with beginners? Why?*

The three methods are—textbook recitation, informal lecture and individual laboratory work. Tabulation shows:

Textbook recitation.....	14
Lecture	26
Laboratory work	27
All three equal	4

Here we are confronted with diversity of opinion for, as a matter of fact, no one knows which is more valuable. No one has as yet applied experimental methods to determine the value of any method of teaching chemistry. Each teacher pursues his own method, that usually which he saw used in his college, and considers it as the best. Teachers are equally divided as to the value of the laboratory and lecture, and yet a large number regard the

textbook as most valuable. Each teacher defends his own opinion, but as these are of little value, we shall mention only a few here, for example:

"Laboratory more important because I believe that adolescents do not know a thing they do not actually do. They simply can not read scientific literature."

"Lectures are not adapted to teaching high school pupils."

"Lectures. Saving of time and apparatus."

"Laboratory, for the pupil gains most of his own activity."

"Laboratory. They think better when they see what occurs."

"Lecture. More and better results in the same time."

"Text. Because it is definite and they can prepare it."

"Lecture. Immature pupils cannot read English, and get lost in laboratory details."

"Laboratory. Memory and interest are better."

"Lecture. Interest, impart more information and make practical applications."

"Lecture. Too little ground is covered in the laboratory, and too much is memorized by textbook recitations."

"Text. It keeps up the interest best."

"Text. Because the pupil has not had time to get over the study methods he got in the grades."

XII. Which method do you use most?

This also relates to the previous question but, as an interesting fact, we find that teachers do not use most, the method which they regard as most valuable. In several instances, a teacher regards laboratory as most important, and uses textbook recitations most. This is true also of other combinations of text, lecture and laboratory. There seems to be an inconsistency here. We find that teachers use most the methods in the following order:

Laboratory	27	Lectures	14
Textbook	18	All equal	8

By comparing with the table just above, we find that there is little correlation existing; for example, twenty-six regard the lecture as most valuable, yet only fourteen use it most; fourteen regard the text of greatest value, and yet eighteen use it the most; and twenty-seven regard the laboratory as most valuable and use it most. In opinion and practice in laboratory work alone is there agreement. Lack of equipment, inability of the teacher to get results, discipline and training of the teacher may be responsible for this inconsistency.

XIII. How do you make chemistry real?

Most teachers are agreed that chemistry should be related to the problems of daily life, to the industries of the community, to the household, and to all the practical relations in which the student may be interested. The replies to this question show that the teachers are trying to bring the student to a greater appreci-

ation of the commonplaces about him. To interest him in the chemistry of the things which touch him daily will make chemistry real. Teachers express this in various ways:

- "Problems of the home, school or possible vocation."
- "Through laboratory and trips to industrial plants" (3).
- "Apply it to everyday things and industries" (4).
- "By study of daily life processes and manufactures" (2).
- "Keeping in touch with history, commercial and household chemistry."
- "Making application to daily life" (11).
- "Reference to common articles of commerce and their manufacture."
- "Constantly calling attention to application and visits to plants."
- "Study real things and let theory go for itself."
- "Doing analytical work for the city."
- "By applying it to the problems of living."
- "By visiting industrial plants, using lantern slides, pictures, and showing the products."

The substance of most of these propositions is about the same, that is, to relate it to daily life, make it concrete by visits to plants, and use material from the pupil's own environment.

14. *Do you use periodical literature?*

One of the more recent developments in chemistry teaching is the introduction of periodical literature. Students read technical magazines, papers, etc., and report on these in class. The development of chemistry is so rapid, and so comparatively new, that current literature alone can bring the facts down to date. This serves to bring the chemistry home to the pupil as nothing else will do. It helps to make chemistry real.

In reply to this question, thirty-one schools answered "Yes," but sixteen of these said only "a little," meaning, no doubt, that no formal reference was made to it. Several schools no doubt have periodicals around, which the student has access to, but this is not using them in teaching. There were thirty-seven teachers who said they use none at all.

XV. *What should be the nature of chemistry?*

Results:

Descriptive	48
Industrial	48
Daily phenomena	52
Laws and theory	31
Analytical	16

The results here seem to show that teachers have come to regard the descriptive and industrial phases of chemistry as of more importance than theory and analytical determinations. This indicates the long way chemistry has gone from the original high school chemistry of 1880, which was almost entirely analytical. Of course, no one teacher would say that chemistry should be all

descriptive or all theory, and this is indicated in the figures, showing the greatest frequency between the first three. This is also contrary to the college requirements which have had a tendency to make the chemistry largely theoretical and mathematical. The chemistry of daily phenomena with such mathematics and theory as are necessary to make it intelligent seems to be the basis of the present subject matter of high school chemistry.

XVI. *Can you offer any suggestion as to how we might improve chemistry in our high schools?*

This question would no doubt be answered largely with reference to the individual school or teacher's experience, and while it might offer some valuable material it would, in only a general way, indicate the conditions and the possible solutions. We might here quote some of the suggestions given:

"Do more for the pupils in practical and vocational direction."

"Separate boys and girls after first half year—boys taking a practical course, girls taking domestic science."

"By employment of proficient men teachers."

"More applied chemistry in college for prospective teachers."

"Get rid of the idea that it is a course preparatory to college."

"The sooner we get away from texts that are abbreviated editions of college texts the better."

"Keep working. Every one's problem is a little different."

"Have college entrance requirements made more flexible."

"Connect with real life—local industries and daily phenomena."

"By not trying to teach too much, especially of chemical theory."

"More training on the part of the teacher."

"Relating it closely to the community, and avoid teaching in cookbook fashion."

"We are at present covering too much ground. A few essentials of chemistry with manifold applications will . . . better chemistry."

"Cooperation of teachers. Do away with textbooks. Use the projection lantern. Have more time for study."

"Have better equipment so more things might be demonstrated."

"Addition of more experiments illustrating the principles of chemistry in the life of the world."

"Leave out as many as possible of the laws and make them secondary to the more interesting parts."

"Give general chemistry the first term and branch out into industrial work the second term."

"By making theories and laws and problems secondary to the more interesting parts."

"Laboratory work is too far removed from life. We do too much laboratory chemistry and not enough everyday chemistry."

"Limit the requirements. The colleges should consider that many laws and theories are too difficult for the average pupil and should be eliminated. We should have two or perhaps three courses in the school, one general chemistry preparatory to college, the second mostly organic preparatory to domestic science, and third a course in the technical or industrial chemistry."

These suggestions are more in the line of complaints against the present conditions in our high school. Very prominent is the feeling that college domination narrows and limits the present

school course and, while this is true to a certain extent, the college domination is rapidly declining. There seems to be a feeling also that the course should be more practical and less theoretical. It should touch the common, everyday occurrences, and the laboratory should be more closely connected with the community. Teachers feel that there is entirely too much theory and problem work in the high school course which ought to be more largely descriptive and explanatory in character. The lack of efficient training for chemistry teaching is everywhere evident. We find here two pleas for better trained teachers. Probably ninety per cent of the high school teachers have had no special preparation for teaching chemistry other than chemistry courses in college. Moreover, there are very few colleges that give any such training, either in chemistry or pedagogy. A chemistry teacher needs a broad training, not only in chemistry, but in science in general, as well as in pedagogy. Again, we find that some are advocating different courses for boys and girls, either from the beginning or after the first term. This would probably meet the requirements of girls far better than the present arrangement. The interest of girls is probably more along the line of domestic science than metallurgy. There is also no doubt that we are trying to cover too much ground to do effective work. We try to cover the text, regardless of how well it is done. Finally, chemistry in any locality is largely an individual problem relative to the community, and every teacher must understand his community in order to solve his problem.

VALUE OF EDUCATION.

Statistics from the high schools serve only to reinforce this proof of the material value of education. As computed by the Massachusetts Board of Education, the difference between the average earnings of the high school graduate and the child who leaves school at the end of the grammar grades is astonishingly significant.

Average weekly earnings of the high school graduate:

At 18 years	\$10.00
20 years	15.00
23 years	21.00
25 years	31.00

Average weekly earnings of pupils who leave school at end of the eighth grade:

At 14 years	\$ 4.00
18 years	7.00
20 years	9.50
23 years	11.85
25 years	12.75

SHORT STORIES OF GREAT INVENTIONS.

BY A. L. JORDAN,

*Polytechnic High School, San Francisco, Cal.**(Continued from February.)*

12. THE DIRECT CURRENT MOTOR. The "immortal Faraday" (as some one has called the great British electrician) was the first to produce rotation by the action of a conductor and a magnet (1821). The "star wheel" motor of Barlow, which was only a toy, followed in 1824. The first practical motor was built by Davenport in Vermont in 1834, and a few years later the Russian Jacobi had a motor which propelled a boat. These, of course, were limited in power and expensive in operation, being run by batteries; but with the advent of current from dynamos, everything was changed, and motors for industrial purposes at once entered many fields and may now be seen running everything from a phonograph to one of our government's giant colliers.

13. THE ELECTRIC RAILWAY. The story of the electric railway is, of course, interwoven with that of the electric motor. The motor of Davenport, mentioned previously, was built for a model of a railway car; and in 1838 Davidson, in Aberdeen, Scotland, tried a locomotive "using a Jacobi motor." A small railway car was operated by Farmer in 1847, and a reversible car by Thomas Hall in Boston in 1850. Page (of the Smithsonian Institution) attempted a large scale experiment, using Grove cells, in 1857. Last in the "battery list" is Green of Kalamazoo, Mich., who made a trial in 1875.

Credit for the first railway using dynamo current goes to the firm of Siemens & Halske (founded by the Siemens Bros.). It was shown at the Berlin Exposition in 1879; and they followed it with a commercial road in 1881. The year 1882 saw a small experimental line (using an overhead wire) built by Van de Poele at Chicago, and the following year at the Exposition, a locomotive built by Field and Edison was exhibited. The first successful experiments of Frank J. Sprague were made in 1883 also, and in 1886 his cars were in operation on the New York "Elevated." Leo Daft attracted attention by a trial on the Baltimore and New York Railway of his locomotive, called the "Ampere," in 1885. The first use of electric cars on a really large scale was that on a railway terminating at Richmond, Va., in 1887.

It is the personal recollection of the writer that electric cars were on the streets of San Diego, Cal., in the same year; and there were no trolley wheels flying off either, for the wheels pinched the wire by the aid of a spring, and the little contact-carriage tagged along behind, pulled by a flexible lead attached to the top of the car.

To write of the development of the electric railway to the present-day magnificent trains with multiple-unit control would take much space. Mention only can be made of the high-speed trials on the Berlin-Zossen Railway, where a speed of 128 miles per hour was reached, the limit being found to depend upon the roadway; of the complete electrification of some steam railways, and the use of electric locomotives in tunnels and on steep grades by others; of the development of the series-parallel system of control; and, recently, the automatic regulation of acceleration; of the perfection of single and polyphase railway motors; of the storage battery cars for special work; of the great field of electric mining locomotives; of the arrangements for supplying power—overhead trolley, underground conduit, third rail, and other sliding-contact schemes; of the wonderful signaling and protective systems; of the circuit breakers, car lighting, electric heaters, switches, and what not, not to mention the coincident history of the Westinghouse air brake.

14. THE POLYPHASE MOTOR offers another example of those remarkable coincidences in the history of science. From 1848 to 1870, the activity of a large number of inventors resulted in the building of many kinds of dynamos, some of which were direct current, some single-phase alternating current, and some polyphase. The currents of the various phases of the polyphase machines were used separately, however, as single-phase currents.

The first man to combine more than one phase and so produce a "rotating field" was Walter Bailey, who in 1879 exhibited a small motor before the Royal Society of England. This depended for its operation upon the currents induced in metal (on the plan of Arago's "rotations" in 1825). It was regarded as a toy, however, and quickly forgotten. Depretz made the suggestion of using the "overlapping" of fields from a two-phase circuit in 1880, but nothing came of it. In 1886 Tesla in this country and Ferraris and Dobrowolsky in Europe independently brought out rotating field motors.

The remarkable feature of these motors is the entire absence

of commutators and collecting rings, and their world-wide adoption for the great bulk of constant-speed power-driven machinery (except for rather small powers) is a matter of recent history.

15. **THE ARC LIGHT.** The tiny spark seen by Volta in using his new battery was really the first arc, but the blinding "arch" produced by Davy between carbon points soon after 1800 (using his great battery of two thousand cells) attracted public attention.

We hear of an arc lamp built by Foucault in 1844, which was steady enough to use for photography, also of a few attempts at arc lamps by Wright (1845) and Staite (1847) in England. In 1876 a short street length in Paris was lighted by the Jablochkoff "candle" (parallel carbons separated by an insulator, alternating current used). The first commercial two-carbon arc lamp was put on the market by Charles F. Brush in 1879. Other men added improvements; as Marks (enclosing globe, 1889), Bremer (flaming arc, 1901), Steinmetz (magnetite arc), and Cooper-Hewitt (mercury vapor arc, 1901).

16. **THE GREATEST ELECTRICAL DISCOVERY** was undoubtedly that of electromagnetic induction. Again we have the coincidence of discovery by two men, both of whom had been working on the problem for a long while. Faraday in England in 1831 made known his results to the world, but found and generously acknowledged that Joseph Henry in America had anticipated him by one year. Faraday is usually credited with the greater share of the discovery, not only on account of first publication, but also because he did more. His work underlies the dynamo, the induction coil, the transformer, and all current induction apparatus.

He was followed by a host of inventors. Pixii (at the suggestion of Ampere) made a small dynamo machine in 1832. Sturgeon (about 1838) added a two-part commutator to the elementary dynamo, and the Abbe Nollet constructed a form of magneto dynamo having a disc armature in 1849. Improvements were made in Europe by Dal Negro, Saxton, Poggendorff, and Wilde, and by O. and F. H. Varley and by Farmer in this country. The important matter of self-excitation was hinted at by Brett (1848), Sinsteden (1851), and Hjorth (1855), but all had in mind coils of wire on permanent magnets. In 1867 Dr. Werner Siemens in Germany and Sir Charles Wheatstone in England independently proposed the self-exciting plan, the former with a "series" connection, the latter with a "shunt."

Going back a little to the matter of the armature, we find that the first important change from the form with bobbins was made by Werner Siemens, who introduced the shuttle or "H" armature in 1856. A toothed ring armature was invented by the Italian Pacinotti in 1864, but it fell into oblivion, being reinvented by Gramme in 1870, whose smooth ring armature became at once of industrial importance. In 1873 von Hefner-Alteneck modified the Siemens shuttle by producing what is now the slotted drum armature.

The compounding feature was set forth in theory by John Hopkinson (Eng.) in 1879, but the first commercial machine is said to have been built by Brush. The compound dynamo invention has been claimed for Sinsteden (1871), Varley (1876), Field, Edison, and Siemens, separately (during 1880), Swan (1882), Swinburne (1882), Shuckert (1883), and was patented by Crompton & Kapp in England.

The advantages of lamination date from the work of Foucault on "eddy currents" in 1850, but were pointed out in connection with dynamos by Gramme. A patent on laminated construction was taken out in this country by Edward Weston in 1882.

This long list may well close with mention of the work of Lord Kelvin, who assisted in developing the modern dynamo (1881); of Gordon, who built large two-phase machines in the same year; of Elihu Thomson, who patented the interpole or commutating-pole dynamo in 1885, this being a modern form of the "slotted-pole" dynamo suggested by the late Silvanus P. Thompson several years before.

17. THE INCANDESCENT LAMP had its very beginning in the hands of Davy, who heated platinum wire with a battery of voltaic cells in 1801, but, being in air, it burned out rapidly. Professor Jobard of Bussels in 1838 suggested the use of a "small carbon in vacuo," and Grove, in England, is reported to have made a platinum wire "lamp;" but the first patent for an incandescent lamp was that issued to Starr of Cincinnati in 1845. No use was made of it, owing to lack of cheap current. The first commercially successful carbon filament lamp in this country was that of Edison in 1879. Swan, in England, seems to have worked independently of Edison and at the same time. Sawyer and Mann should also be mentioned in the commercial development of the lamp.

The carbon lamp held its own for many years, and while Staite (Eng.) patented an iridium filament lamp in 1848, and the Amer-

ican Bottome patented a tungsten filament lamp in 1887, both, like Starr's lamp, seem to have been forgotten. The search for a metal filament lamp went on, however, and von Welsbach (inventor of the incandescent gas mantle) produced a lamp with a filament of osmium in about 1900; later, two Austrians, Just and Hanaman, produced one form of tungsten filament (1903). Several German investigators were pressing forward along the same lines, and two of them, von Bolton and Feuerlein, invented a tantalum filament lamp in 1905. From 1907 to 1909, Kuzel, von Bolton, Welsbach, and others worked on the tungsten lamp, and improvements have been added (such as decreasing the fragility of the filament) by men in the great manufacturing companies, as Siemens & Halske, the British Thomson-Houston Company, and the Westinghouse and General Electric Companies here. Last, and most important of all, has come the "nitrogen-filled" or high efficiency tungsten lamp which runs almost to the "half-watt per candle power" (as against about 1.2 for the vacuum lamp), and it is made in such large units that it rivals the arc in power and is replacing it for street lighting, for large interiors, for projection lanterns, and even for searchlights (as in "flood lighting").

These improvements, together with the fact that increased voltage causes a greater resistance (instead of less, as with carbon), have caused a wonderful growth in its use. Its need of less attention in service also gives it an advantage in the rivalry with the arc lamp.

The only improvement of importance in the carbon lamp since it left Edison's hands in about 1880 is a process of making the filament harder ("metallized"), so that it will operate at higher temperatures with consequent increase in efficiency (2.5 watts per c. p. instead of about 3.5).

One remarkable incandescent lamp is that of Nernst (Ger.) in 1898. The filament is of a specially treated kaolin, which has the strange property of being an insulator until its temperature is raised by a heating coil. It then glows with a beautiful white light, and, although the filament is in air, it oxidizes at an extremely slow rate. It lends itself especially well to certain uses, as picture galleries (where its slow lighting up is of no great disadvantage); and while the cost of the lamp is an item, the "glower" is renewed cheaply. Its efficiency is also quite high.

(To be continued.)

GENERAL SCIENCE,

BY HARRY A. CARPENTER,

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The topic of general science is an exceedingly broad and difficult topic to discuss. All over the country today, there seems to be the demand for a course in general science, and recently a good many textbooks have been written with the titles, *General Science*, *Elementary Science*, *Introduction to Science*, etc., and these textbooks should be taken as representing the trend of thought along the line of general science teaching. That the concept and purpose of general science has many angles and has many opponents as well as many friends is to be expected.

In order to introduce the topic, I would like to consider for a moment the questions, "Why should we teach science?" and "What are the purposes and results anticipated?" Science has not always been taught in our schools after the customs of today. Time was, when physical science received almost no recognition as an educational subject. What has occurred in the last twenty years to make the teaching of science in our high schools more and more necessary?

In attempting to answer the questions, I feel somewhat like the colored preacher who rose before his congregation of a Sunday morn and said, "Brederen, dis mawnin' I'se gwine to define fer you de indefinable, I'se gwine to explain de inexplicable, I'se gwine to unscrew de inscrutable." Certain it is that the great demand for science teaching and better science teaching depends directly upon the fact that since the days of Lavoisier, Bunsen, and Boyle, science has made a tremendous inroad in the number of pages in the book of knowledge. In no other field of learning has there ever been such enormous progress in a hundred years, yes, in fifty years, as shown by the development of modern science. Thinking back but a generation, we do not find the universal telephone, the transcontinental telephone, nor the ordinary telegraph in its present high development, not to mention the wireless telegraph and telephone. The automobile that is so necessary to our business world today was then only a toy; the flying machine existed only in the mind of "Darius Green." And I say that the reason why we must teach science in our schools is because a great proportion of human knowledge of today is of a scientific character.

One of the purposes of teaching science is to give the student

information and he who would teach science must select the items that are worth while. For example, whoever writes a book on special general science presumes to pick out from the mass of possibilities those items which he deems either most useful from the standpoint of the home, or of educational training, or most fitting for further and more detailed study of science later on. An examination of most of the general science textbooks which have been recently published discloses the fact that the selection of items of information has been to a large extent influenced by the individual taste and training of the writer. In other words, a specialist in biology will write a general science textbook, and the items of information which he deems most useful and necessary are unquestionably those items of biology with which he has most to do, and so his text is biology with certain extracts of information from other fields of science. In exactly the same way, the specialist in physiography builds his course around the physiographic items of information, I have made the preceding statements with a view to showing you that the selection of items of information for a course in general science will most likely depend upon the particular field in which the author is more or less a specialist.

I should say that these items of information which are to be selected for the youth of our nation should and must depend upon the particular environment of the pupil. The boy or girl from the immigrant home in our cities must have a different need from the boy or girl who has been raised and is living on the farm, and again a different phase of the topic must be presented to the girl who comes from the home where she is not expected to take any part in the home duties. The selection of items of information is one that only the man on the job can do since he is the only one who can see to the best advantage the needs of the particular pupil. If we are to teach general science, and if we are to begin the teaching of that general science in the grades below the high school, I should say unhesitatingly that items of information should be drawn from the *home, street, and health environment* of the boy or girl. These items should be chosen and so grouped as to give unity, and they must be progressive in character. They must be so presented by the teacher as to make the pupil believe that he is initiating something. The pupil must be made to feel that he is contributing to the general welfare of his class and his teacher, his home, and town. In other words, the pupil from the beginning must

be made to feel that he is a *producer* in every sense of the word.

A second reason for teaching science which almost every teacher will give is training, and here again I ask, "For what?" Are we going to train our boys and girls to become specialists in biology if that is our field, or are we going to train them to be specialists in electricity if that is our interest? For what are we going to train our boys and girls? I understand the word training to have the significance of mental training as well as a training for some vocation or profession. Hence we must answer both questions.

As to training accomplished by the study of either special or general science, I believe it should impress upon the pupil the great moral question of truth, it should teach him the moral question of duty toward others and toward himself, it should so train his mind that he will at least begin to study properly, that he will form the beginnings of the proper habits of attention, that he will form the habit of reading a paragraph critically and of selecting from the topics those topics of most importance. In other words, the training should give him the beginnings of those mental functions which are so necessary to the successful citizen, proper mental habits, independence of thought, and high moral standards.

From the industrial or practical standpoint, science should train the pupil for something useful, there should be a definite object in the mind of teacher and pupil. Here I wish to quote from papers written by pupils studying general science in the seventh grades of our Junior High School in answer to the question, "Do you find the study of the history of stones interesting?" I am selecting one or two at random from a large number that are equally to the point. A girl says, "I think it is very nice to know all about the different kinds of stones, and I think it is also very valuable because it is helpful to us in many ways when we grow older. For instance, if we wanted to be science teachers it would be much easier to learn when we have had it when we were small, and also if boys wanted to be masons or any other trade that has to do with stones it would be helpful to them in many ways to know all the things about stones which we learn about in science." Another girl says, "It is interesting to study the history of stones because when going anywhere and finding a peculiar stone, friends are always interested in asking the name of it." A boy says, "I find the study of stones very interesting because I am interested in the earth and because of the

minerals which it contains." Another girl says, "I find the study of stones interesting because it is a study of natural things that teach us a good many things. They help men when they become contractors to know the stone and its qualities without having to be taught because it was taught him when he went to school." I have given direct quotations taken from the papers which show that the boy and the girl in the seventh grade are looking ahead to what they are going to do, and so I say science teachers must consider "Training for what?" Please notice also the references made to the fact that they are coming to "know things without having to learn them" which expresses a great pedagogical principle.

If I should ask you for still another reason for teaching science, you would undoubtedly say "Culture," and Yankee-like I ask, "What is culture?" Does culture consist in the ability to read the classics, in the ability to talk intelligently of the great literary writers of the past and the present and the possibilities of the future? Does culture mean the ability to paint a beautiful picture or to appreciate art? Again I say, "What is culture?" As a definition of culture, I am going to give a quotation taken from an article in the *North American Review* of October, 1915, by A. Lawrence Lowell. He says, "So far as culture is concerned, our problem is to develop in harmony with our own institutions a type of education that will cause young people to enjoy the things the world has agreed are beautiful, to be interested in the knowledge mankind has found valuable, and to comprehend the principles the race has accepted as true. This is culture, and to impart it is the function of the American college." To Dr. Lowell's wonderful conception of culture, may I presume to add that to impart this culture is a function of the *whole educational system*? Culture, like the morality, cannot or should not be taught abruptly after a textbook method, but the science teachers must constantly and adroitly impress the intangible elements of culture and morality upon their boys and girls. There is perhaps no better vehicle for the subtle teaching of moral truths and acts than science. Certainly, no field of knowledge offers any greater opportunity for culture, as defined by President Lowell, than science.

If we have agreed that science shall be taught in our schools whether as general science or as specialized science, we must inevitably come to the discussion of the method. An examination of the most of our science textbooks today, chemistries, phys-

ics, biologies, astronomies, etc., shows an attempt on the part of the author to present the facts of the special science from the *logical viewpoint* to the very best of the author's ability as a *mature student*. And then this same mature scientist, having so presented his thoughts, expects the *immature pupil* of the high school or the seventh or eighth grade of the public school to accept these facts in the same logical order. Permit me to quote from President Butler's annual *Columbia University Report* of November 2, 1914, concerning this question. What he says is directed to the university teachers, but I would like to apply the same statement to the elementary and high school science teachers. He says, "The two mistakes into which college teachers are most likely to fall are, first, that of failing to give the students such primary and introductory explanations as will serve as an academic chart for the voyage to be undertaken, and, second, that of confusing the logical with the psychological order of presentation of facts. The real good teacher knows that the logical order is the result of mature reflection and close analysis of a large body of a related phenomena, and he knows, too, that this comes late in the history of intellectual development. He knows also that the psychological order, the direct order for the teachers to follow, is the one which is fixed by the intrinsic value and practical significance of the phenomena in question. The good teachers will not try to force the logical order of facts or phenomena upon the immature student." If what President Butler has to say of the teachers of college students is true, how much truer it is concerning us, and yet I respectfully call your attention to the fact that our textbooks are fashioned after the logical method of mature minds, and yet we wonder why the student fails to comprehend. Some one has aptly stated the difference between the logical and the psychological method by saying that we should have the student "heft the thing, not weigh it."

An ordinary, casual study of the statistics concerning the science education in the United States, together with discussions of science teachers over the country, brings one inevitably to the conclusion that the method of teaching science almost wholly as special science as has been done in the past dozen years is unsatisfactory. Examination of the United States Bureau of Education reports shows that in the past twenty years there has been a decided decrease in the amount of special science called for in our public high schools. If our students, advised by their teachers, are taking less and less of the special science,

there must be a tangible reason to explain the fact. Why do our boys and girls neglect the study of science to such an increasing extent? One of the reasons undoubtedly is that science teachers come before the students as specialists fresh from their college training, and expect and hope that their young boys and girls will absorb and assimilate the same type of science with which their college training has saturated them, and they have been inclined, therefore, to discourage many students of certain types of mind from pursuing their subjects. Especially in physics the high degree of quantitative accuracy demanded by many good teachers has discouraged many of our students. In fact, the time has not long since passed when many students deliberately planned that it would be necessary to spend two years to get the credit for one year's work in physics, because of the large number of failures. To a less extent perhaps, these facts are true in other courses. I have already referred to the fact that the textbooks in science are for the most part unsuited to the immature mind. Another reason why the science election by pupils has diminished is the pressure put on them for the study of classics, history, etc., because the majority of teachers are more directly interested in these subjects than in science. For example, in a small high school of six or seven teachers, probably only one will be interested primarily in science, and hence the bulk of advice for students actually comes from the six other teachers, whose primary interest is of a classical character. Moreover, the type of physics and chemistry taught for the most part in our high school is such as to induce many college professors to say they would as soon a student would enter college without those special courses as with them. Also, the work has not as a rule given the student much worth while for the needs of life. Our colleges and our merchants and manufacturers want boys and girls who can *think*, not repeat.

It is evident then that a rearrangement of our science methods and science topics is necessary if we are to succeed in developing a more and more increasing interest in science on the part of our pupils and give them something worth while. This reorganization must extend from the high school into the grades if we would produce the best results.

You will all admit, I think, that it is impossible for any one student in the high school to take a year or even a half year of consistent work in each of the special sciences, biology, botany, zoology, physical geography, geology, astronomy, physiology,

physics, chemistry, etc., and yet I think not one would consider for an instant omitting all references to astronomical facts simply because the special subject of astronomy for various and good reasons is not generally advised as best for the high school. Neither would you cut off all information concerning botany or the weather, simply because a student was unable to spend the required amount of time in those special sciences. If you admit this fact, we are forced to the conclusion that all students should be given such an elementary training in general science as will introduce them to some of the more interesting and more useful parts of each of the sciences. This, I believe, is the justification for general science. I would not have you suppose that I would do away with the study of special science as a special subject, but I do want you to understand that I am decidedly in favor of all students getting a certain minimum amount of training in the fundamentals of science thought, of science information, and in the scientific method, and that I believe that this should be started below the high school. The time was when our English teachers taught their work under the head of rhetoric, composition, grammar, English literature, American literature, etc., and now we find the progressive English teachers are teaching English, they are teaching the rhetoric and composition always wherever and whenever these special subjects most readily suit the purpose at hand. Another reason why I believe that we should teach our students some fundamental general science is because today we must supply for the city boy and the city girl those experiences which they have missed and which the boy or girl on the farm or the village has obtained. This first-hand information and observation must be produced somewhat artificially for these young boys and girls who, because of their environment, have been unable to acquire it naturally.

In order to better our science teaching then, I would say that it is necessary in the first place to reorganize our science methods and to rewrite our science textbooks for the study of the special science. I believe that it is necessary to offer as preliminary work to the subject of the special science a certain carefully planned course in general science. In order to do this, it will be necessary to extend the study of science into the grades below the high school, preferably as low as the fifth and sixth grades. To accommodate a satisfactory reorganization of our science work, it will be necessary to increase the length of the school day. To obtain the best results of the study of science, it will be

necessary to have study more closely supervised by teachers who themselves know how to study. If you will think back into your own experience, you will find that the great majority of your questions do not provoke any higher type of mental action than memory. In fact, nearly the whole fabric of our text work in science is founded upon that one form of mental activity, memory. I believe that if we would best train these young minds, we must diminish the number of questions that require repetition only, and increase the number of questions which require thought. Certain it is, that a teacher of science, whether it be general or special science, cannot go before his class and ask questions which stimulate thought without thoughtful daily preparation, whereas too often we find teachers asking questions that come to mind at the instant.

In order that our general science and our whole science study in the elementary and high school shall be of the greatest value it will be necessary to give our students special guidance in their choice of subjects. It was my duty to assist boys just entering high school to copy their registration blanks and, when these blanks were passed out for them to copy, several boys called my attention to the fact that the schedule did not contain the subjects they wished to study. For example, they pointed out that they did not want to study "that stuff," called Algebra or Latin, but that they wanted to take electrical or mechanical engineering. And here again I want to call your attention to the fact that these boys, like those boys in the seventh grade to whom I referred earlier, are looking ahead and planning on what they are going to do in the world.

The old idea that a study of Latin, for example, even if disagreeable to the pupil, is of value because it gives the pupil the habit of accomplishing a disagreeable task, with the view that this habit of "overcoming the disagreeable task" would be transferred to some other subject which might be more to the liking of the student, is superseded by the more rational psychology today. We agree that "disagreeableness is not necessarily educative." We hope that habits formed in the study of one subject are transferred and utilized in the study of other subjects, but one of the great reasons why study of Latin is so much worth while is because of the continued study of one subject. In other words, a pupil begins the study of Latin in the first year of high school, or before, and continues constantly to study the topic of Latin throughout the high school course, and if he goes to college he

will continue to study Latin for another four years. It is this continued application of his mind along a definite road that gives him the power to transfer the ability gained here to the accomplishing of tasks in other lines. I would claim for science that same great advantage if we can have a continued study of science. I would suggest then, for your consideration, the reorganization of our science work on the following basis: Granted that our science work today is not entirely satisfactory, granted that science teaching is of the utmost importance, I would recommend then that our science work be started in the early grades of the grammar school and that this science work be continued by teachers who are suitably equipped to give it the consideration and thought necessary for success. I would suggest that this science for the grades in the grammar school and for the first year, and perhaps the second year, of the high school be what is known as general science in that it is not a special science. I believe that in the first year of high school the general science would naturally take the trend of a biological character, since our boys and girls are then at the age when they should be impressed with the great physiological and hygienic views necessary to their good health. The second year of the high school general science should quite possibly take the trend of physical science. The student arriving then at the third year of his high school experience will have had more than four years of consistent, carefully directed study and thought along the lines of general science. He will be prepared to enter profitably into the study of any of the special sciences, physics, chemistry, physiography, botany, etc., that environment and need indicate. Best of all, if he never goes further than the end of the second year, he will at least have that peculiar enrichment of mind and experience that cannot be obtained except through science study. Let us treat the immature mind psychologically to develop the logical mature mind.

CLASS ROOM SAYINGS.

Slang is vulgar use of words usually hanging around the outskirts of a town.

Simultaneous equations are solved by *exterminating* one of the unknowns.

A boy in beginning algebra was asked to explain his solution of a system of linear equations involving x and y . He replied that he would first *illuminate* x .

SHUNT GENERATOR.

By E. C. MAYER,
 Cornell University, Ithaca, N. Y.
 (Continued from February.)

PART III.—LOAD CHARACTERISTICS.

A. Introductory.

The potential difference between two points in a circuit is defined as the work done in transferring a unit quantity of positive electricity from one point to the other. From Ohm's law, it follows that the potential difference between two points between which there is no E. M. F. along the path traveled may be expressed as follows: $\phi d = IR$, in which ϕd is the potential difference, I the current flowing, and R the resistance between the points considered. Whenever a current flows through a resistance, there is always a disappearance of electrical energy. The energy reappears in some other form as in heat.

The E. M. F. of a battery or a dynamo is equal to the greatest possible potential difference between its terminals; that is, when the generator is allowed to give no current, being on "open circuit." As soon as the generator is allowed to give current, the circuit being closed, the difference of potential between its terminals no longer equals its E. M. F., but is less, owing to a loss of potential due to the work done in sending current through the generator itself, the generator having resistance. The loss of potential inside the generator will be equal to the internal resistance multiplied by the current flowing. From the above, we get the following expressions for a simple circuit:

When no current is flowing, $E = E_T$ between the generator terminals.

When a current is flowing, then $E_T = E - I_A R_A$ (2)
 where E_T is the potential difference between the generator terminals, E the E. M. F. of the generator, R_A its resistance (resistance of armature circuit), and I_A the current flowing through it.

The external shunt characteristic of a shunt generator is a curve which shows the relation between terminal voltage and external current. If a generator rotates at rated speed, and has a definite field current, it will generate a certain E. M. F. Upon closing the external circuit through a resistance, a current will

flow through the armature and the external circuit. Whenever a current flows through an armature, there is a drop of potential, according to the discussion above, so that some of the voltage induced by the generator will be used up in the armature, and the remainder in the external load circuit. This may be written in the form of an equation (2) as above.

As the machine delivers more current, the terminal voltage is decreased, due to the increased IR drop in the armature. Upon decreasing the external resistance more and more, a point may be reached where the external current no longer increases but actually decreases. Upon decreasing the external resistance still further, the current continues to decrease, until, when short circuit is reached, there is only a small current flowing.

B. Data.

The connections are shown in Figure 8. Connect an adjustable resistance suitable for carrying large currents in series with an ammeter and the brushes of the generator. Connect the

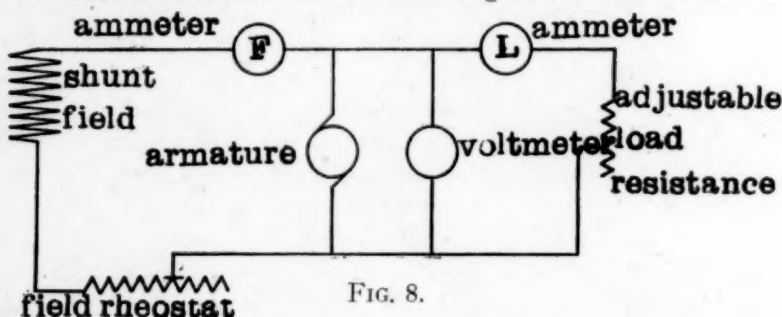


FIG. 8.

voltmeter across the brushes. No speed correction is made. The field rheostat is set in one position (for normal voltage at no load) and no change is made during the run. Readings are taken of terminal voltage, E_T (voltmeter reading), field current I_F (reading of ammeter F), line current I_L (reading of ammeter L), and speed for various resistances in the circuit, until the voltage E_T is low enough for the machine to be completely short-circuited. Finally, measure the armature resistance R_A . See Appendix A.

C. Curves.

The armature $R_A I_A$ drop is plotted as ordinates, and observed line current I_L as abscissas. $I_A = I_F + I_L$.

For the external shunt characteristic, plot observed line current I_L as abscissas, and terminal voltage E_T as ordinates. For

total shunt characteristic, plot total armature current I_A (line current I_L plus field current I_F) as abscissas, and total generated voltage E (terminal voltage E_T plus $R_A I_A$ drop) as ordinates. Illustrative curves are shown in Figure 9; and a convenient data table is given at the end of the appendix.

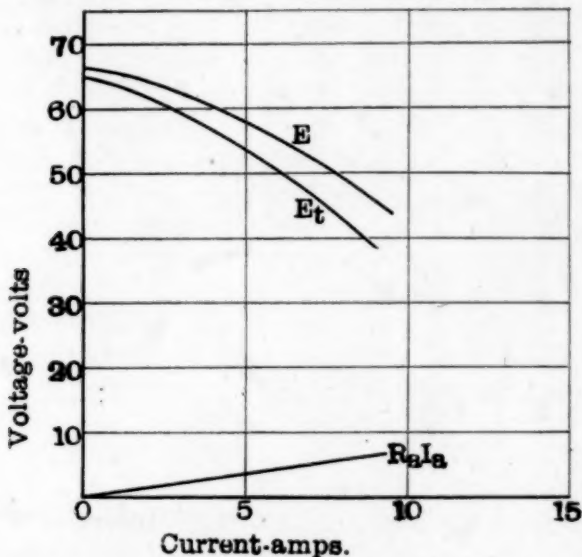


FIG. 9.

D. Questions.

1. Interpret the curves fully.
2. Why is it desirable that the armature resistance of a generator be made low?
3. Explain why the terminal voltage of a generator tends to decrease with increase of external current.
4. For what reason may a generator refuse to "build up," and what action is the necessary remedy?

PART IV.—APPENDIX.

A. Fall of Potential Method for Measuring Resistances.

This method is based upon the fact that the fall of potential through a resistance R carrying a current I is $pd = RI$ (Ohm's law). The resistance R which is to be determined may be the resistance of any conductor whatever (armature, etc.) which is not the source of E. M. F. An armature therefore must be stationary while its resistance is being measured by this method. Connect the unknown resistance to a source of direct current

through a regulating resistance. See Figure 10. Take readings of the two instruments simultaneously, and without delay. The resistance R is equal to E/I .

B. General Directions on Practical Operation of Dynamos.

DYNAMOS (Generators and Motors): By means of a rope or chain, attached to the eyebolt with which a dynamo is provided, it is lifted and moved from place to place. When moving, care must be exercised so that the armature windings do not suffer abrasion.

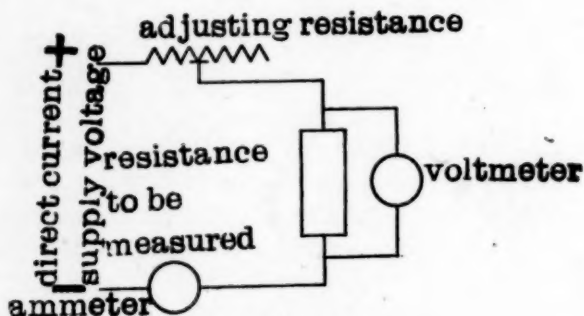


FIG. 10.

Whenever the machine is not in use, it is to be covered with a waterproof covering, and is to be kept clean and dry in all circumstances. Upon starting a machine which has been idle for a considerable time, its action must be observed carefully and closely for some time, in order to detect any defects which may have developed.

If a dynamo is not known to be dry, it is assumed to be moist, and treated as follows: Dynamos which are moist or wet are run several hours with the field winding unexcited. Then the field is very slowly excited to its normal excitation until the dynamo runs at rated output.

ARMATURE: Whenever the armature is being removed from the dynamo, it must be handled with the utmost care so that abrasion of the windings is avoided. An armature must not be placed upon the floor or other hard support, but is to be put upon a soft bed of sacking.

BEARINGS: Keep thoroughly lubricated.

BELT: The tension of the belt of a belted dynamo is adjusted by means of a device by which the dynamo is moved bodily on suitable supports.

BRUSHES: When the pressure of the brushes upon the com-

mutator is too great, there is excessive friction, and when too small, there is chattering of the brushes, which is harmful to the brushes and commutator alike, causing sparking and roughening of the surface. A normal operating pressure is 1.5 lbs. per square inch of contact surface.

The brushes are to be lubricated sparingly.

COMMUTATOR: Excessive use of oil on the commutator causes sparking and the collection of dust and particles of carbon which offers poor electrical contact with the brushes.

The commutator may be cleaned by pressing a piece of tightly wound cloth which is free from lint into contact with it when revolving. A little vaseline is then put upon the cloth and thence to the commutator to give the necessary lubrication.

STARTING: Before starting a shunt generator, it is well to see that all contacts and screws of the machine are tight. The oil cups are to be provided with oil, the oil feed properly adjusted, and all oil ducts and passages should be clear. Whenever oil ring bearings are used, the rings are to move freely, and to dip into the oil reservoir.

The belt is to be turned by hand at first to see whether the machine runs freely, and also whether the belt runs in the center line of the pulleys.

Then connect a voltmeter across the brushes, see that a suitable fuse is in each lead wire from the generator, also connect an ammeter on the load or external circuit side of the main switch, and set the circuit breaker, which should also be inserted on the load side. The shunt field rheostat is set for maximum resistance. Start the engine (prime mover), and generator, slowly bringing the generator up to full speed. Decrease the field resistance until the voltmeter registers almost rated voltage. Close the main switch, and readjust the field rheostat to obtain the exact terminal voltage. To stop the generator, increase the field resistance to a maximum, and open the main switch. Then stop the driving engine.

If the circuit breaker opens, due to an overload or external short circuit, open the main switch, set the circuit breaker, and finally close the main switch.

C. References.

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BLAKER: *Experiments in Physics*, 1914, pp. 184-186, 198-202.

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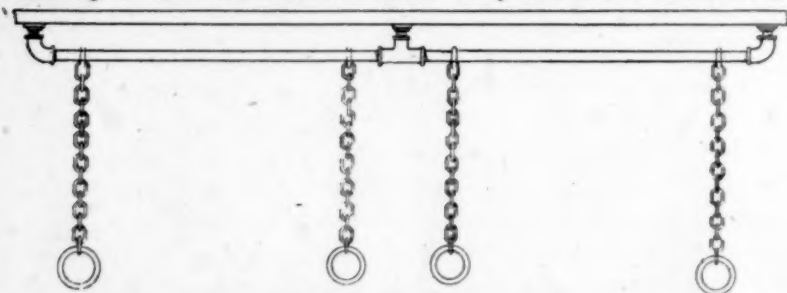
Observed				Computed		
I_F	$E_T = E$	R. P. M.		E_T Corrected for assumed constant speed		
E_T	I_F	I_L	R.P.M.	I_A	$R_A I_A$	$E = E_T + R_A I_A$
			R_A			

CEILING SUPPORTS.

BY JOHN C. PACKARD,
Brookline, Mass.

The following device, recently installed in the physical laboratory of the Brookline, Mass., High School, has been found to be convenient and useful.

An oak board, 16 feet long by 4 inches wide, carrying two travelers made of gas pipe, is securely bolted to the ceiling over the center of the demonstration table. From as many iron rings sliding along the travelers hang four iron jack chains, the lower end of each chain dropping to a point just within reach above the top of the demonstration table. By the use of an S-hook



in connection with this device, a 30-pound spring balance, a commercial block and tackle, or the hook of a long lever can be readily suspended in full view of the class. The height above the table can be regulated by means of a supplementary hook and chain, and the position along the table can be readily adjusted by sliding the upper ring along the traveler. Suspension over the pneumatic trough is especially convenient when weighing articles submerged in water in connection with the various applications of Archimedes' principle. When not in use the chains hang quite out of the way and are at the same time always available.

THE IMPROVED DERRICK AS USED IN THE PHYSICS LABORATORY FOR THE STUDY OF GRAPHIC STATICS.¹

BY FRANK R. PRATT,

Rutgers College.

In finding the resultant of a given number of vectors, the student is given usually a force table apparatus, or the forces are applied on top of the laboratory table where all the forces lie in a horizontal plane. Of course, the reason for this is obvious. We wish to avoid the action of gravity upon the several parts of the apparatus. Hence, when the student has a problem where the vectors lie in a vertical plane, he fails to see that the same laws which he found with the horizontal force table may be applied to this case.

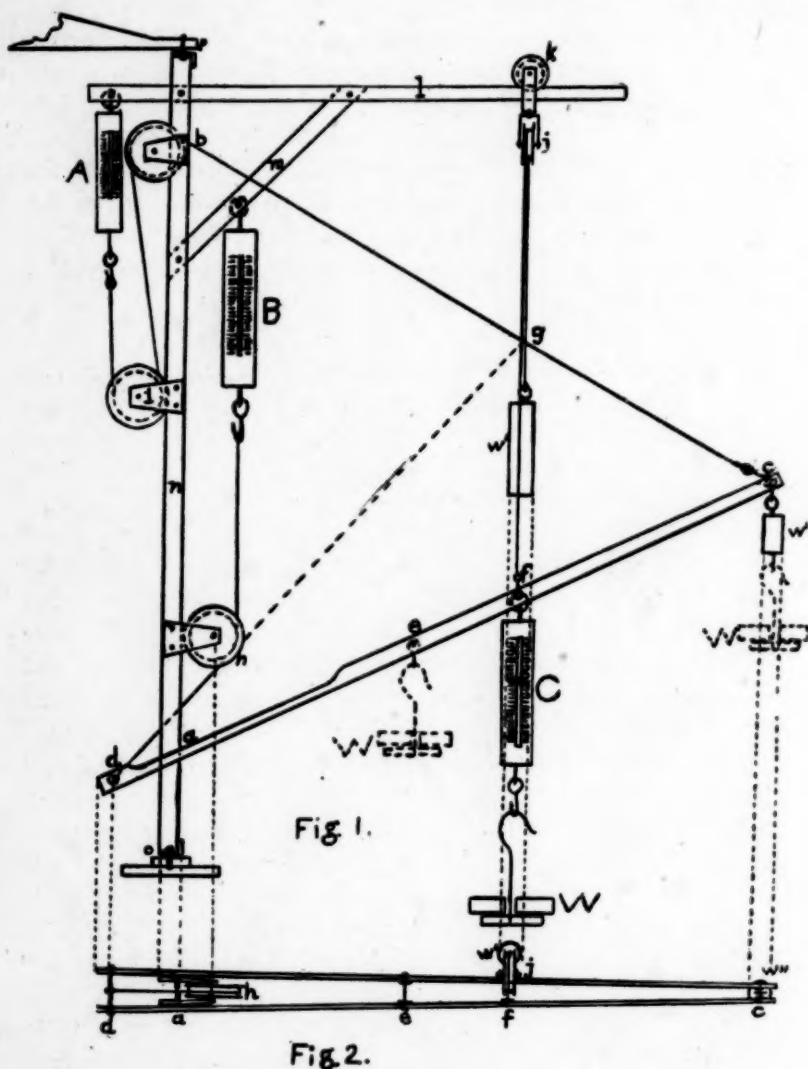
One of the best methods for helping the student to fix these laws in his mind is to give him some work with the derrick. The derrick, as it is constructed for practical work, has several serious defects for use in the laboratory. The weight of the beam must be considered, the reaction of the beam must be measured, and the direction of this reaction known. Unless the weight lifted by the derrick is placed at the center of gravity of the beam, we have at once a complex case of two weights, viz., weight of beam and added weight. The reaction of the beam is measured usually by taking vertical and horizontal components. Hence we start out to prove the simpler case of composition of forces, and have to perform the more difficult case of resolution of forces first.

I searched the catalogs of several supply houses and found none of them sold a derrick which eliminated the above difficulties. I wished to use the derrick because I believe our laboratory apparatus should help the student to solve the problems he will meet in practical life. I also wished the derrick to help explain the problems found in Shearer's *Notes and Questions in Physics*, page 48. The following is a description of a derrick I designed to meet the above requirements. I have been experimenting on this model for the past three years, and now believe it to be without a fault. My college and summer school classes have used it with marked success, and I find it makes this whole subject very clear to all who use it.

Figure 1 shows a side view of the derrick as constructed.

¹This derrick is being manufactured by Standard Scientific Co., 147-153 Waverly Place, New York City.

Figure 2 shows a top view of the beam. The beam is made of two pieces of inch and a quarter by one-eighth inch iron, 100 cm. long, placed side by side far enough apart to slide easily outside of the vertical post. The vertical post consists of two pieces of



three-quarter inch angle iron, 115 cm. long. These are placed with the flat side out and the inner edges far enough apart to allow the chains supporting the beam to pass freely between them. Both ends of the beam are supported by these chains.

The upper and lower ends of the vertical post are fastened to rigid supports by pivots o and p . These allow the derrick to turn on a vertical axis.

Weight w'' is adjusted until the center of gravity of the beam falls at f . A chain fastened at f passes over the pulley j and down to the weight w' . Weight w' is adjusted until the beam with the spring balance C will take any position whatever. In other words, weight w' eliminates the pull of gravity on the beam and balance. Spring balance C registers the amount of weight W applied to the beam. Spring balances A and B register the amount of tension on the chain supporting the upper end of the beam and the reaction of the lower end of the beam, respectively. Weight W is five kilograms, and the pan weighs five hundred grams. The chain is common window sash chain, and the pulleys are sash pulleys. The weight w' is a sash weight, and w'' is a lead weight. Weight W may also be applied at e or under w'' as shown by the dash lines in Figure 1. Hook c may also be applied at e or f , hence it is possible to make nine different combinations. The beam is cut away where it meets the vertical post at a in order that the upper edge shall be in line with the center of bolts c , d , e , and f .

After applying the weight W, only one adjustment is necessary. Pulley k must be rolled along on track l until the chain ff is vertical. This is easily done because weight w' is a plumb bob. The pulleys being quite large, there is little friction, and a slight jar overcomes this. Pulley i might have been omitted by passing the chain under pulley b and having balance A higher up. I preferred to use pulley i for several reasons. First, it makes the derrick more like those used by engineers. Second, it makes the derrick more compact. Third, it brings balance A to a lower level where it is easier read. Fourth, pulley i is made adjustable and can be raised and lowered easily, thus changing the position of the beam. Fifth, the weight of the long chain cb is counterbalanced by chain from b to i , hence balance A gives the true force at c .

It is not necessary to know trigonometry to use this derrick. No angles are measured, therefore no functions of angles are used. In making the force diagram of this derrick, the sides of the triangle abc are measured and laid off on the paper to some convenient scale. The lengths of cf and ad are also needed. The three forces being in equilibrium must meet at a point; that point is g . Notice that the short piece of chain dh extended by the

dash line hg passes through the point g . The chain ff crosses the chain bc at g , and, by laying a meter stick along the chain dh , the student sees that dh extended would meet the other chains at g . The student not only knows the amount of the reaction as read from balance B, but he sees the direction in which the force acts, and it removes from his mind the erroneous idea that the beam always pushes endwise.

The student, having point f located on his paper, draws fg parallel to ab , cutting bc at g , and then connects g with d , giving the direction of the reaction of the beam. A vector drawn by proper scale equal to W is laid off from g along gf or gf extended. From the lower end of this vector, a line is drawn parallel to bg , cutting hg , and a vertical line from this cutting point completes the parallelogram. By means of the scale used to lay off the vector equal to W , the student finds the tension and the reaction from the tension and reaction lines, respectively, as they extend from the point g and become the other side and the diagonal of the parallelogram. The values read from balances A and B are used only as a check on the values found by scale.

A scale in centimeters is marked along one side of the beam, beginning with the zero at the upper end. A scale in inches might be added on the other side. A vertical scale might be placed on the side of the vertical post, but this would need to be adjustable since the point where the chain bg meets the post n varies when hook c is moved to f or e . The spring balances A, B, and C read in both the metric and English units, and have a capacity of fifteen kilos. If the pulleys were made with real good ball bearings, the slight jar to produce equilibrium might be omitted.

To sum up the advantages of this derrick: It is cheap, simple, strong, durable, and never gets out of order. The weight of the beam is eliminated. The effect of the weight of the beam may be shown at once by raising weight w' . The amount of the reaction of the beam is measured, and the direction of this reaction plainly shown. The intersection of the lines of the three forces in equilibrium is marked by the crossing of the chains at g . The amount of weight applied to the derrick and the tension on the chain supporting the upper end of the beam are shown by balances C and A. Weight of chain is compensated. No angles used. Easy to manipulate and make diagrams. It fixes the laws in the student's mind so that he will never forget them.

**GEOGRAPHIC INFLUENCES IN THE DEVELOPMENT OF
THE MECHANICAL ARTS OF ANCIENT EGYPT.**

BY DEETTE ROLFE,
Champaign, Ill.

The origin of the mechanical arts has been ascribed both to Egypt and to Babylonia. Undoubtedly, a similar and quite independent development occurred in the two countries. In Egypt, it was due primarily to phenomena connected with the inundation of the Nile, and in Babylonia, to the Tigris-Euphrates.

Throughout all of Egypt's history, the control and proper utilization of the flood waters have been largely responsible for whatever measure of prosperity and well-being she has attained. Without these, the country could have been little else than a barren waste—water-covered and water-soaked a part of the year, and later, for several months, a stretch of wind-driven sand, glistening under the heat of the subtropical sun, and not differing much in appearance from the desert which lay on either side. At these times, vegetation could have existed only in isolated depressions which had impounded the water and retained it longer, and there it might have developed into oases of veritable jungle. Such a land would, of course, be utterly unfitted for agricultural pursuits. The time elapsing between the subsidence of the water sufficiently for sowing, and the parching of the soil by the burning suns and drying winds, would be all too short for the maturing of crops. A small amount of herbage might spring up and become large enough for pasture, but little else would be possible.

It is thus small wonder that man's first efforts when he came into the Nile Valley should have been in the direction of making for himself a more habitable dwelling place. As long as the people lived on the desert their life was more or less nomadic, and they cared little for a settled abode or a settled occupation. They traveled from one oasis to another, and, as their wants were few, they managed to eke out a rather meagre existence while living a life of indolence and irresponsibility. When they came into the valley, however, a new set of conditions confronted them. The flood, unless controlled, presented itself as an annual menace, before which they had to flee every June from their abodes near the river. They could, under such conditions, have no permanent dwellings, and their

state would have been in some ways worse than on the desert itself. The water, however, contained elements of prosperity, denied to them in their desert habitat—but in return were demanded toil and thought. Nature was most lavish in her gifts, but man must do his part, if he proposed to wrest a living from the Nile Valley.

The early Egyptians were thus powerfully stimulated, both intellectually and physically, by the conditions of their environment, and, long before our knowledge of history begins, they had succeeded in reclaiming restricted areas by means of canals which directed the course of the water during the flood and retained a part of it for use later in the year. This probably also included the working out of plans for gates, sluices, etc.—crude at first, but of a higher grade as their mechanical skill developed.

It was no easy task for a people just emerging from barbarism to evolve even the beginnings of such a system of water control, and it probably could not have been done had the need been less urgent. Their very life depended upon working out this problem. Its solution was no less than a triumph, and its reaction upon their mental processes was of even greater importance than its effect upon the land. Their faculties, thus sharpened, were ready to attack new problems with increased energy. Little wonder, then, that by the time of the Sixth Dynasty, Egypt reached almost the zenith of her mechanical attainments. Little wonder, too, that Menes was able to plan and to carry through the gigantic task of so diverting the course of the Nile as to make room for his new capital city of Memphis; that Menere conceived the idea of canalizing the lower cataract; that Amenemhet was able to add to Egypt's wealth by his remarkable works in the Fayum, and that the great pyramids came into existence.

The capacity for organized work and for steady, unremitting toil, which developed as the result of solving the irrigation problems, was an important factor in preparing for the erection of the pyramids. From the quarrying of the great blocks of stone to their final arrangement as parts of the pyramid, the mechanical skill of the builders was taxed to the utmost, and it developed in proportion. The use of wooden wedges in the quarries is but one instance—and a small one—of their ingenuity. These wedges, which were first well dried, were

driven into grooves in the stone and then wet thoroughly. The expansive force with which they swelled was sufficient to separate the block from the main mass of rock.

Egyptian mechanics were essentially practical. There was no development of theory and abstract ideas; means were conceived and inventions were made for meeting special needs as they arose. Consequently, there was little or no explanation of mechanical principles. The shaduf, for instance, was a typical Egyptian product invented as the simplest means of raising water from the irrigating ditches onto the land, and it dated from pre-dynastic times. It introduced and made use of the principle of the lever. In moving the great stone blocks of the pyramids, the same principle was again brought into use. There seems, however, to have been no development of the theory of the lever, and, as a result, it is the name of Archimedes—Greek scholar of the third century, B. C.—which is now associated with it.

The river frequently changed its channel in time of high water¹ and methods of restraint had to be devised such as the making of stronger dikes at danger points, changing of the current, etc. Property rights became involved whenever there was a change in the channel—when the bank caved in, or when a neck of land was cut through. As a result, methods of land measurement and of land surveying had to be developed. This was made necessary also by the fact that many of the landmarks were obliterated each year by the flood, and had to be renewed at planting time. Taxes were dependent upon land area, and its determination was thus a matter of great importance to the officials. For the proper construction of the canal dikes and a fair distribution of the water, a crude running of levels was necessary. In supplying these and similar needs, the science of geometry is supposed to have originated.

The construction of the Nilometers and the computations following their use advanced the science of numbers. Long and involved calculations were sometimes necessary to determine the amount of water which each bit of land might receive, and the taxes due therefrom. The Rhind Papyrus² gives the solution of some of these problems. The custom of storing away great quantities of grain in the government granaries and its subsequent

¹This was especially the case in the delta, where the low grade of the river made it particularly easy.

²The Rhind Papyrus is a mathematical handbook which has been preserved in the British Museum.

sale or division among the people also necessitated the use of mathematics.

The very early date at which a science of mathematics must have been evolved in Egypt is suggested by the calendar. This was introduced in 4241 B. C.³—more than eight hundred years before the kingdoms of Upper and Lower Egypt were united. It is significant that the calendar year began with the inundation.

The absence of roads—the utter impossibility of their existence—and the universal use of the river and canals for all communication are reflected in the early development of shipbuilding. Conditions were particularly favorable to traffic on the Nile.⁴ There was, at all times, sufficient current to carry a boat downstream, and, as the prevailing wind was from the north, by the use of sails it was also possible to go upstream. A pre-dynastic painting shows such a boat with a single large sail.⁵ The pyramid blocks were usually brought down from the cataract during periods of high water when the current was strong, and when they could be taken directly to the site they were to occupy.

³Breasted's chronology. For a different view, see G. A. Reisner, *The Egyptian Conception of Immortality*, p. 40.

⁴Adam Smith (*The Wealth of Nations*, I, 18) suggests the importance of inland navigation in the early development of Egypt.

⁵Budge, *History of Egypt*, I, 80.

TREE CISTERNS.

The baobab tree (*Adansonia digitata*), a member of the hollyhock family common in the Sudan, is one of the freaks of the vegetable world. It has a large bottle-shaped trunk, which, though scarcely reaching the height of sixty feet, is often more than a hundred feet in circumference, and is therefore one of the largest of plants. The stubby branches, which spring mostly from the top of the stem, are so broad that the natives can sleep on them. The interior of the trunk is soft and spongy and, as in other trees, may decay and form large cavities in which rain water accumulates. Acting upon this hint from nature, the natives of Kordofan have hollowed out the trunks of many specimens, and in the rainy season fill them with water for use when the rains cease. A hole is often bored near the base by means of which the water is drawn off as wanted. In a recent *Kew Bulletin*, a note from an officer in the Darfur campaign mentions these trees as follows: "On our side of the border in Kordofan, they have no water for perhaps hundreds of miles and live in the dry season on water stored in hollow trees called tebaldis. They are ugly, bottle-shaped trees, all trunk, from six feet to twenty feet thick, and a good one holds 1,000 gallons. Each family owns certain trees and each tree has its own name. They scrape a small pond at the foot, and after a shower everybody turns out to fill tebaldis trees. A man stands at the top of the bole, about twenty feet up, hauls the water up in a skin bucket, and pours it into the tree. It keeps very sweet and is better than well water. The fruits of the baobab are oval, brownish green, about the size of a cucumber, and contain an edible pulp of which the monkeys are very fond. From this fact the tree is sometimes called the monkey bread tree.—[*American Botanist*.

RECENT TENDENCIES IN THE TEACHING OF ELEMENTARY APPLIED MATHEMATICS.

By J. R. YOUNG,
University of Nevada.

HISTORICAL STATEMENT.

The mathematics given in the elementary and secondary schools of the United States in the latter part of the eighteenth and the early part of the nineteenth centuries was largely of a very practical character.¹ Arithmetic was recognized as a preparation for business and commerce. Even a superficial survey of a few of the early texts brings conclusive evidence to support this statement. The first arithmetics used in America were English works. One of these which was most widely used was Hodder's *Arithmetic: or, That Necessary Art Made Most Easy*, of which I have examined the twenty-third edition published at London, 1705. The chapters 17 to 23 are devoted to problems of a distinctly commercial nature. The *New and Complete System of Arithmetic*, by Nicholas Pike, published in America, 1788, was a practical arithmetic, the later problems dealing extensively with business relationships. *The Scholar's Arithmetic, or Federal Accountant*, by Daniel Adams, the tenth edition of which was published at Keene, N. H., in 1822, indicates both by its subtitle and by the character of the problems that it was intended primarily as a business arithmetic.

Surveying was introduced into the academies in the latter part of the eighteenth century, in response to the practical need consequent upon the conflicting land claims resulting from the Revolutionary War and the opening up of great tracts of virgin territory. It has kept its place in a large number of secondary schools and in the colleges as a disciplinary subject since it has lost its practical *raison d'être*. That the subject is taught with little attention to practical considerations is shown in the fact that many long and involved methods of solution are employed in the classroom which are never used by the practical surveyor.

Algebra and geometry were developed quite fully as college subjects before they were introduced into the secondary schools. Their field of application to practical affairs is much more circumscribed than is that of arithmetic. These subjects were consequently developed and organized from the disciplinary point of view. With the growth of our commerce and the building up of a class which could afford the time to study subjects

¹ Cajori, *A History of Elementary Mathematics*, p. 217; D. E. Smith, *The Teaching of Arithmetic*, p. 33.

which were not of immediate practical value, there arose a demand for algebra and geometry in the academies and high schools. With the introduction of these two subjects and the extension and organization of the mathematics in the secondary schools, the abstract, disciplinary, pure science ideal of the colleges became dominant in the mathematics in the secondary schools. The advanced arithmetics designed for the use of the secondary schools became the models for the writers of texts for the elementary schools. As a result, the arithmetics of this period (roughly from 1830-90) began to lose their practical direction. The drill problem, the involved problem having no relation to the conditions of real life, and the puzzle problem² became prominent. The mathematical gymnastic was the order of the day. The slight preponderance of problems dealing with business over those of any other field is the only reminder we have of the fact that the early arithmetics were intended primarily as a training for practical business life.

During the period characterized above, applied mathematics was taught by the masters of apprentices and in a very limited number of technical secondary and higher schools. As early as 1850, the apprenticeship system began to break down, and from that time to the present there has been a growing demand for a more practical training in the public schools. In the last ten years, this demand has become very insistent. Mathematics, along with the classics and many of the other subjects, has been placed upon trial from the point of view of its practical value for the mass of our people. Mathematicians and educators have not been unmindful of this jury of the people. They have testified freely against themselves, and some have even pronounced their own sentences. They have established many new schools of a practical character, and have incorporated vocational courses in the curricula of the regular schools. The point of view is changing rapidly, but the practice is changing slowly.

Superintendent Morrison, in a very able article,³ outlines some of the fundamental principles which should govern the reorganization of the subject of mathematics:

1. There is general dissatisfaction with mathematical instruction.
2. Subject matter must function throughout the process of learning, and it is impossible that the present mathematics should function even in the hands of skilled teachers.

² It is of course true that this type of problem is found in limited numbers in some of the earlier arithmetics.

³ Morrison, Henry C., "Reconstructed Mathematics in the High School," in Part I, *Thirteenth Yearbook, National Society for the Scientific Study of Education*.

3. The courses of study in mathematics must be reorganized so as to meet social needs.

4. Detailed, concrete aims, related to social needs, must replace the formal and disciplinary aims.

5. The courses in mathematics should be differentiated along cultural and technical lines so that they parallel the broad zones of adult activity.

This tendency toward applied mathematics in the non-vocational schools has already passed beyond the realm of mere theory. A number of textbooks have been written which embody the practical point of view. Of these, the Young and Jackson series⁴ may be taken as typical. In the preface, the authors state that the effort throughout has been to select problems which are practical, applicable to daily life, and within the experience of the children. Each of the three books contains one or more sections upon "Applications of Processes." In Book I the section on applications contains problems concerning areas, weights, marketing, sales checks, bills, volumes, and two groups of miscellaneous problems. Book II contains three sections on business applications and one on practical problems of measurement. In Book III there are extensive sections dealing with the applications of percentage, interest, and banking; forests, lumber, railways, ranches, plantations, and orange groves; and commercial problems including ordering goods, recording sales, bills, receipts, and stocks and bonds.

A further step in the direction of applied arithmetic is taken by Burkett and Schwartzel in their *Farm Arithmetic*.⁵ This text is intended to be used in the last two or three years of the elementary school. The point of view of the authors, as stated in the preface and directions to the teacher, is of interest: "There is much in modern arithmetic that is of little value to certain classes of pupils. Particularly is this true of the subject matter of many textbooks now in use in rural schools—country, town, and village. These books were made by city people for city children, and are, for the most part, admirably adapted to city schools." "Arithmetic may be taught in terms of agriculture. On the other hand, agriculture may be taught in terms of arithmetic." This purpose of teaching agriculture through arithmetic is evidently kept in mind throughout, for the problems are both chosen and stated in such a way as to emphasize the best agricultural methods. In addition, the arithmetic contains many "Important Truths" interspersed among the

⁴ Young, J. W. A., and Jackson, *Arithmetic*, Books I-III, Appleton, 1904.

⁵ James Baldwin's *Industrial Primary Arithmetic*, Ginn & Co., 1891, is an earlier example of the same general type. In this book a special effort is made throughout to show the pupils the practical uses of numbers.

problems. The following is typical: "Hogs return to their owner the greatest relative profit if sold at an age of from six to nine months. They then weigh between 150 and 200 pounds. Hogs weighing from 300 to 400 pounds are usually sold at a loss. Only when feed is cheap and prices high can heavy hogs be produced at a profit." There are many good illustrations and many series problems in which the pupil may identify himself with the farmer in the latter's determination to drain his field, spray his trees, etc., share in his first discouragement through the lack of immediate improvement, and in his ultimate success and satisfaction in the increased production of orchard and field.

The emphasis upon inventional and constructive geometry, and the effort to combine the most practical aspects of algebra, geometry, and arithmetic in single texts for use in the elementary schools are also, in large measure, a result of the demand for applied mathematics.

COURSES OF STUDY AND METHODS OF INSTRUCTION.

In Corporation Schools.—One of the recent developments in the field of industrial education is the school for apprentices conducted by a corporation to train competent workmen for its several departments. These schools represent a very high degree of specialization; and the aim of developing an efficient workman dominates the school. Everything that cannot be made to harmonize with this aim is eliminated. We may note first a few general statements as to the instruction in these schools.

In a description of the methods employed in the Browne and Sharpe School, at Providence, R. I., the writer says: "The instruction is conducted mainly without textbooks and by direct means, working from the particular problem and its solution up to the principle. Practical problems are taken up as they would occur in the shop. Such reference books and tables are at hand as any progressive mechanic would have, and the students are taught to use them in solving the problems. These problems are worked in blue-print form, and the sheets are preserved by the boys in suitable covers. The blue prints follow a careful gradation in the difficulty of the problems, and the directions given are explicit."⁶

A bulletin of the School for Apprentices of the Lakeside Press, Chicago, describes the course of study given in that school as follows: "Mathematics is taught from the shop point of view,

⁶ Report, Commissioner of Education, 1913, I, 260.

and accuracy becomes not merely the idea of getting the answer, but is absolutely necessary when applied to practical work. Arithmetic is reviewed from the factory side. An applied arithmetic has been prepared to be used in connection with the review work. The elements of algebra and geometry are taught, and whenever possible the problems are applied to the trade."

The outline of the course of study in mathematics for the Lakeside Press School is given as follows: "Arithmetic, Applied—Review of fundamental work as outlined in applied arithmetic; the technical work of the text completed; supplemented by actual problems constantly arising." "Algebra, Elements (Wells)—Applied work as far as possible."

Mr. Sheldon, Supervisor of Apprentices, says that he finds that the number of algebra problems which can be directly applied to the printing industry is exceedingly limited, and that in geometry the principal points of contact are found between constructive geometry and the department of design.

The course of the School of Apprentices of the Lakeside Press may be taken as typical of the courses in those schools which plan to give a relatively broad training. A number of these schools teach no mathematics except arithmetic. A few have no special courses in mathematics, but teach the subject in connection with the various shop problems as they arise in the progress of the apprentice.⁷

All of the arithmetics used in these corporation schools are apparently a direct outgrowth of the work in the shops for which the apprentices are to be trained. C. J. Hicks thus describes the evolution of the textbook used by the Harvester Company: "For several years the shop class instructors have been preparing and using special arithmetic lessons, and the present textbook is a combination of these lessons and a direct outgrowth of the work at the McCormick, Deering, and Milwaukee works."⁸

I have examined five of these applied arithmetics.⁹ These books are all "pocket editions." None exceeds a hundred pages. All of the authors of these books agree that a comparatively small amount of arithmetic *well taught* is all that is necessary for

⁷ Cf. Report of Committee No. VI, Intern. Math. Commission, and Bul. Bu. of Ed., 1912, No. 4, p. 35.

⁸ Bulletin of National Association of Corporation Schools, No. 9, November, 1914, p. 34.

⁹ E. E. Sheldon, *Applied Arithmetic*, Lakeside Press; Colvin and Cheney, *Machine-Shop Arithmetic*, New York Central Lines; Santa Fe System, *Apprentice School Arithmetic*; Eaton and Brady, *Ludlow Textile Arithmetic*; *Handbook of Arithmetic and Geometry*, Fore River Shipbuilding Company, Quincy, Mass.

workers in the industries. These texts differ somewhat as to organization and points of relative emphasis. In most of the texts the shop problems are organized under the regular arithmetical rubrics,—Addition, Fractions, Ratio and Proportion, etc. In the *Machine Shop Arithmetic*, however, the organization is largely under shop captions, as Rules for Selecting Change Gears for Screw Cuttings, Speed of Pulleys, Gears, Cutters, Drills, etc. There are differences also in the methods of approach. The *Ludlow Textile Arithmetic* quite uniformly presents under each topic definitions or rules, drill problems, and then problems applied to the industry. The approach is conventional. On the other hand, in the *Santa Fe System Arithmetic* there are practically no rules or definitions, and there is little organization to the problems that points to any special method of approach. In general, however, a limited number of drill problems are first presented when a new topic is introduced. One of the things which comes forcibly to the attention of even the casual student of the Santa Fe arithmetic is that it was printed entirely without consideration of the eyes of the apprentices. The print is exceedingly small. The Lakeside Press arithmetic is the only one of the group which devotes a number of sections to general, relatively abstract problems, "thinking exercises," as the author of the text calls them. These problems are given in the first half of the book, the last half being devoted almost entirely to problems of the industry. The *Machine-Shop Arithmetic* is distinctive in that it gives a very small number of problems in connection with each topic, while the explanations are relatively elaborate. The principle is emphasized throughout as the essential thing. A considerable number of algebraic formulas are elaborated in this text. The book used by the Fore River Shipbuilding Company apprentices is the only text in which there is a section on practical geometry. An outline of the table of contents may be of interest as shown on the next page.

Tables are given in the back of the book, including decimals of an inch, squares, cubes, square roots, cube roots, logarithms, reciprocals, circumferences, and circular areas of numbers from 1 to 1,000. The problems are almost all in terms of shipbuilding, and there is a minimum of simple definitions. The geometry is largely constructive, and it is evidently intended to prepare for mechanical drawing or to supplement it.

A few distinctive features of the methods used in these schools

may be noted. In the Santa Fe System Apprentice School and the Harvester Company's school, a single leaf textbook is used. Each pupil is given an outline of the course and a folder in which to keep each sheet of the arithmetic as it is given to him. In this way, concentration is secured and the students may advance individually. Even the simpler problems are presented in terms of the industry. In this way, the apprentice gets accustomed to the applied mathematics point of view, and at the same time

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Definitions.....	3
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builds up his shop vocabulary. In the *Ludlow Textile Arithmetic*, a glossary is given in the front of the book to aid the student in his interpretation of the problems and in getting acquainted with the vocabulary of the mills. In the Santa Fe school, one phase of the work deals with the replacement of various articles and pieces of machinery in the shops. The apprentice is given a list of such articles and asked to write out everything that it would be necessary to know in order to replace the missing articles. In this way, exact measurement and statement, names of manufacturing establishments, and excellent drill in various types of shop problems are secured. This work has proved to be exceedingly helpful and interesting to the apprentices. In general, the writers of texts for these schools have succeeded remarkably well in securing clear and simple statements of the fundamental principles of arithmetic, and some of the makers of more advanced texts could study their rules and definitions with profit.

In Secondary Technical Schools.—The report of Committee No. VI of the American Commissioners of the International Commission on the Teaching of Mathematics gives a relatively full statement¹⁰ of the tendencies in mathematical instruction in

¹⁰ See *Bulletin* 1912, No. 4, Bureau of Education.

the secondary technical schools.

The agricultural schools usually devote from six months to a year to arithmetic, most of the problems relating to the life on the farm. About the same amount of time is given to algebra and geometry as in the other secondary schools. Advanced algebra is occasionally taught, and trigonometry is given in about one-fourth of these schools. The committee concludes that the curriculum in many of the schools is not at all affected by the special object of the school. About one-third of the agricultural schools report that the arithmetic work is more practical, while one-fourth say that the methods used have not been affected by the special function of the schools. Arithmetic is the only mathematical subject correlated with agriculture. Algebra and geometry are taught from texts after the traditional method, and few schools make any effort to emphasize or develop practical applications of these subjects. Solid geometry is taught in about twenty-five per cent of the schools. It is evident that many of these schools are following almost exactly the traditional course of study for the secondary schools, but the committee adds the hopeful statement that the curriculum for these schools is still in a formative state.

(Continued in April.)

ALGEBRAIC DERIVATION OF THE LAW OF COSINES.

BY ALBERT BABBITT,
University of Nebraska.

Let A , B , C and a , b , c be, respectively, the angles and the sides of the triangle ABC .

$$A = 180^\circ - (B + C).$$

$$\sin A = \sin (B + C) = \sin B \cos C + \cos B \sin C, \text{ or}$$

$$1 = \frac{\sin B}{\sin A} \cos C + \frac{\sin C}{\sin A} \cos B, \text{ or, by the law of sines,}$$

$$1 = \frac{b}{a} \cos C + \frac{c}{a} \cos B.$$

$$\text{Hence, } a = b \cos C + c \cos B. \quad (1)$$

Similarly, we obtain,

$$b = c \cos A + a \cos C \quad (2)$$

$$c = a \cos B + b \cos A \quad (3)$$

Multiply (1), (2), and (3) by a , b , and $(-c)$, respectively, and adding, we get,

$$c^2 = a^2 + b^2 - 2ab \cos C.$$

Similarly, we obtain,

$$b^2 = a^2 + c^2 - 2ac \cos B.$$

$$a^2 = b^2 + c^2 - 2bc \cos A.$$

A METHOD OF DEMONSTRATING AND TEACHING THE TRIGONOMETRIC FUNCTIONS.

BY S. C. MITCHELL,

Lowell, Mich.

Every student of trigonometry, probably, experiences the difficulty of attaching concrete meaning to that abstract list of figures called the natural function table. Coincident with this difficulty comes the problem which his teacher faces of bringing him to connect the figures in the table with something tangible. Numerous drawings on the blackboard may be used to show different relations, but, somehow, such figures are lifeless things compared with the live changes of values and relations between sides and angles of a right triangle which take place as the acute angles vary between 0° and 90° . It was with the hope that an understanding of these changes and relations might be more readily obtained that the Trigonometric Function Indicator was devised.

This instrument consists of a plane surface upon which is laid out a quadrant of a circle of unit radius. The radius in the initial position is divided into tenths and hundredths of the given unit, beginning with zero at the center of the circle. This we will designate as the Cosine Scale. It is raised above the plane to provide for the free movement of the other parts which must pass under it. It is to remain fixed in this position.

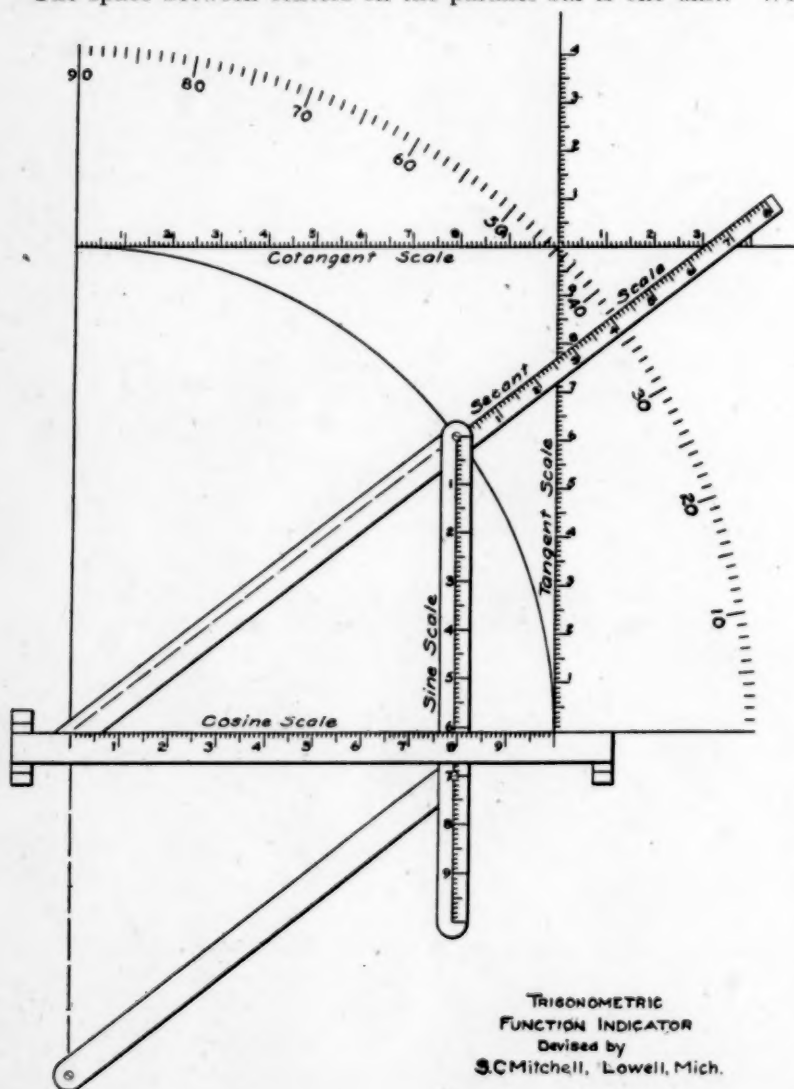
Tangents are drawn at the extremities of the radii which are at right angles to each other. Each of them is graduated in the same fractional units and has the zero point at the point of tangency. The vertical scale may be called the Tangent Scale, and the horizontal the Cotangent Scale. It is evident that these two scales will intersect at their first unit points. The lines are graduated and extended as far as the plane surface will permit.

The quadrant is divided into degrees as indicated. It is placed outside of the circumference of the unit circle in order that its graduations may not interfere with those of the scales.

Attached to the plane surface at the center of the circle is the bar which serves as a generatrix and upon which we have the Secant Scale. It is apparent that, since all secants and cosecants are greater than unity, no graduations are necessary within the circle.

At a distance of one unit from the center, another bar is attached to the generatrix bar, upon which will be placed the Sine Scale. It is graduated in the same way as the others, and

has its zero point at the point of connection with the generatrix bar. It is at least one unit in length, and must be always perpendicular to the Cosine Scale. In order to assure this, a perpendicular to the initial line at the center of the circle is let fall, and at a convenient distance another bar, which we will call, for convenience, the Parallel Bar, is attached to the plane surface. This bar is also attached to the Sine Scale at a distance from its zero point equal to the length of the perpendicular. The space between centers on the parallel bar is one unit. We



thus have a parallelogram formed, and, since the left side is always perpendicular to the initial line, the right side or Sine Scale must be perpendicular to this line also.

We know that the sine of the indicated angle is obtained by dividing the side opposite by the hypotenuse. Now, since the hypotenuse is equal to unity, the reading on the scale opposite must be the natural sine of the angle. Likewise, that part of the Cosine Scale included between the center and its intersection with the Sine Scale must be the natural cosine of the angle. That part of the vertical tangent cut off by the generatrix must be the natural tangent, and the same intersection will determine the natural secant on the Secant Scale. The cotangent and cosecant will be determined in the same way by the intersection of the Secant and Cotangent Scales.

The student is always interested in seeing the actual changing conditions as the generatrix is moved back and forth between 0° and 90° . It is easy to prove to him, with this device, that $\sin(x+y)$ is not equal to $\sin x + \sin y$; that $\sin(x-y)$ is not equal to $\sin x - \sin y$; that $\sin 2x$ is not equal to $2 \sin x$; that $\sin \frac{1}{2}x$ is not equal to $\frac{1}{2} \sin x$.

Space will not permit the description or enumeration of the many uses of this instrument, not only in the trigonometry class, but also in the physics laboratory and the drafting room. Full directions for making one of these devices will be sent to any address upon receipt of fifty cents. Address S. C. Mitchell, Lowell, Mich.

SALT EVAPORATION A BIG INDUSTRY.

In the production of that indispensable condiment, salt, the United States is happily independent of all other countries. The 38,231,496 barrels of salt produced in 1915 by fourteen states, Porto Rico, and Hawaii constituted ninety-nine per cent of the salt consumed in the United States, and much more could easily have been supplied had the demand required it, according to the United States Geological Survey, Department of the Interior.

Salt occurs naturally in two distinct ways—as rock salt, in beds or associated with bedded or sedimentary deposits, and in natural brines. The larger part of our salt is obtained by converting rock salt that lies deep below the earth's surface into artificial brines, which are pumped to the surface and there evaporated. Some idea of the quantity of salt evaporated from natural brines may be gained from statistics of the output of New York, Michigan, and Kansas alone, three large salt-producing states, for the calendar year 1915. In Michigan, 6,708,261 barrels of evaporated salt, having a value of \$3,635,692, were produced; in New York, 3,443,464 barrels, valued at \$1,720,434; and in Kansas, 1,901,756 barrels, valued at \$696,060.

DEPARTMENT OF MATHEMATICS QUESTIONS AND ANSWERS.

Conducted by Herbert E. Cobb.

Lewis Institute, Chicago.

For the many mathematics teachers who are entering the profession every year, and for those who after some years of work and study find themselves at times in doubt concerning questions of subject matter, methods, devices to interest pupils, the history, psychology, or bibliography of mathematics, special problems and the like, this department is established. Probably the question that is perplexing some teacher at the present time has been faced and successfully answered by many others.

It is hoped that many will make use of this opportunity, not only to send in questions, but also to furnish replies to questions already published. Brief discussions, from two hundred to three hundred words, of points brought out in the questions will be appreciated. One or two answers to a question are not to be considered final. Several answers from different viewpoints are desired. Address all communications to H. E. Cobb, Lewis Institute, Chicago.

Answers.

1. What is the most effective way of using the blackboard during a recitation in geometry?

Answer by F. W. Runge, Township High School, Evanston, Ill.

I think the blackboard can be used very effectively, during the earlier weeks, to emphasize a proper form of demonstration. The timid pupil gains confidence by being allowed to read what he has written, with the feeling that at least the eyes of a part of the class are on something other than himself. As the pupil gains in self-control, the authorities are omitted, the pupil supplying these as he reads. Later, only the special enunciation and auxiliary constructions are permitted to appear in detail, and these only to guard against the common error of overloading. Finally, nothing but the figure is drawn by the pupil, and even this is supplied by myself during reviews. Of course the amount of detail in an original demonstration depends upon and varies with the difficulty of the exercise.

I believe that the minimum number of original exercises that should be required of any tenth grade class devoting a year in plane geometry is 250. I usually require nearly 400 of the average class and have frequently handled over 500 successfully.

Answer by L. C. Irwin, High School, Joliet, Ill.

In order to answer the above question, one must determine the purpose of the recitation in geometry. Is it to test the pupil's knowledge of the lesson assigned, is it to test his initiative in using the knowledge gained from the lesson, or is it to direct him in his methods of attack and lead him to the applications of the facts learned? I assume that the latter is the object of most recitations.

In a beginning geometry class, I like to have a member of the class write on the blackboard the proposition assigned, underline the hypothesis, from the hypothesis construct the figure, write the "given" and "to prove" steps, and await his turn to be called upon for recitation. When called upon he should step to the board, read the proposition clearly, explain the figure, and then state in a general way his method of proof. After outlining his method of proof, he should give the formal

proof, and, if the steps seem long or complicated, should write them on the blackboard. In a construction problem, it is well to have the pupil explain his construction as he works.

In the second semester of geometry, the figure only should be placed upon the board and the entire demonstration given orally. Often the next day's assignment may be discussed, some member of the class placing the figure on the board and leading the discussion. The teacher may place on the board a figure, such as an isosceles triangle, and suggest the proof of the equality of the base angles. From this, the pupils should attempt the statement of a theorem, as well as the proof.

The most direct way to a boy's mind is through his eyes. By picturing a theorem on the blackboard, a pupil is led to make mental pictures, and thus his imagination is developed. Most people think best when they see what they are thinking about.

2. About what is the minimum number of original exercises in plane geometry that should be required of a tenth grade class which devotes the entire school year to the subject?

Answer by Mabel Sykes, Bowen High School, Chicago.

It seems to me that the answer to this question must depend entirely on the manner in which the original work is conducted.

I have a certain number of supplementary exercises written out and handed in. No credit is given a pupil for one of these exercises until it is correct. I read the papers, make the necessary corrections, and return them. They are then corrected or rewritten as the case may be, and handed in again. Often the same pupil hands in the same problem several times before it is accepted. When it is accepted, however, it is accepted at full value. To facilitate the keeping of records, I post on the bulletin board in my room a sheet containing the names of the class and the numbers of the required problems. When a problem is accepted, I destroy it and write its number after the name of the pupil on the board. From seventy-five to one hundred exercises are given out in a year in this way, and the best pupils do them all. I have never felt, however, that I had a right to "fail" a pupil merely because he did none of them.

The number of exercises that can be worked orally and often at sight is much larger. This number depends partly upon the easy accessibility of the exercises. This year I have provided myself with a card index file for 3x5 cards that I use for geometry exercises. On each card I have put the figure, the hypothesis, and conclusion of an exercise. The cards are indexed according to subject matter. A large number of the exercises are easy enough to be done at sight. If during the recitation I wish an exercise to illustrate some particular point, I can lay my hands on one at once. The card is handed to some pupil, and later the proof is called for. This plan is the result of a suggestion made to me by C. E. Comstock of Peoria, Ill. I am continually regretting the fact that I did not have the file long ago for supplementary exercises in algebra and geometry.

3. How much attention should be paid to the check in the solution of equations?

Answer by L. C. Irwin, High School, Joliet, Ill.

Mathematics is an exact science and should emphasize accuracy, as well as stimulate an ambition to be right. Checking answers in the solution of equations has this desired result. Evaluation of formulas is a very important, and a very much neglected, phase of algebra teaching. Checking equations is a form of evaluation.

Drill work in arithmetic is the crying need of the day. This need is

satisfied partly by the checking, and the drudgery of the drill is cloaked in another garb.

A desire on the part of the pupil to know that he is right and not dependent upon some one else is encouraged. The checking of the so-called "story" problem tends to aid the pupil in the interpretation of this most dreaded type of problem, and open his eyes and mind to its meaning. Checking should be encouraged and not discouraged, answer books should be discarded, and reading of answers by teachers should be stopped. The pupil should find out for himself.

Answer by Emma C. Ackerman, High School, Lockport, Ill.

The value of the check in the solution of an equation is that it is a check; the pupil is forming the habit of self-reliance in his work. He should not find it necessary to ask, in regard to an equation, "Is this answer correct?" In fact, the habit of checking results is easily formed. However, it is not wise to ask the beginner to check complex results; he rebels rightfully against a process which, to him, is more laborious than to work the example again. In applied problems he should not think it possible to leave the problem till he has satisfied himself that his solution meets the conditions required. Sometimes it is a help to beginners to give the answer as a goal when assigning the example. The experienced teacher will observe that, to the erratic thinker, a check is not always a correction; the errors he makes to force a wrong answer to check are as startling as those to which the wrong solution is due. Even under these conditions the teacher may with care bring about some honest thinking. The pupil may be led to respect the process of checking by assigning an equation that he is not able to solve, perhaps a cubic equation, and asking him to discover whether it will be satisfied for certain assigned values.

Besides the test in accuracy and a drill in exact thinking, the check has the value of emphasizing the nature of the function. The pupil is finding values of expressions, often without realizing it; these processes serve to fix the idea of the function of a variable.

I should think that it would be interesting and helpful to the mathematics student to have an expert accountant, engineer, or auditor state what system of checks he uses in his work; and how valuable he finds it.

Answer by F. W. Runge, Township High School, Evanston, Ill.

I believe that the check of the solution of an equation with simple numerical roots should be understood by the pupil to be an essential part of the operation. I frequently say, "You have not solved the equation until you have found its root or roots, of which you cannot be sure until they have been shown to satisfy the equation." However, the pupil is constantly warned that this is no proof that he has translated his verbal problem into algebraic symbols correctly. He must verify this by examining his answers to the questions asked, in the light of those questions.

QUESTIONS

4. Is there any proof for the methods given in mechanical drawing for the construction of regular polyhedrons of seven, nine, eleven, and so on, sides?

5. Has any teacher used graphs at the very beginning of first-year high school algebra, and used them throughout the course? With what success? Any particular difficulty?

6. Too many of my pupils in solid geometry find the first two or three weeks' work difficult and dreary. The proofs are short and not easy to remember, and there are no numerical exercises. What can be done to relieve the situation?

PROBLEM DEPARTMENT.

Conducted by J. O. Hassler,
Englewood High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics. Besides those that are interesting per se, some are practical, some are useful to teachers in class work, and there are occasionally some whose solutions introduce modern mathematical theories and, we hope, encourage further investigation in these directions. All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. In selecting solutions for publication we consider accuracy, completeness, and brevity as essential. Address all communications to J. O. Hassler, 2301 W. 110th Place, Chicago.

Algebra.

496. Proposed by Felix A. Ciampi, New York City.

Solve the simultaneous equations:

$$x^2 + y^2 + x + y = 1. \quad (1)$$

$$x^4 + y^4 + x^2 + y^2 = 1. \quad (2)$$

Solution by the Proposer.

In (1) transpose $x + y$ to the second member and square:

$$x^4 + 2x^2y^2 + y^4 = 1 + x^2 + y^2 + 2xy - 2x - 2y.$$

Rearranging and subtracting from (2), the following is obtained:

$$2x^2 + 2y^2 - 2x^2y^2 + 2xy - 2x - 2y = 0.$$

This may be written in the form,

$$(x-1)(y-1)(xy+x+y) = 0.$$

$$\text{If } x-1=0, x=1, \text{ and } y = \frac{-1 \pm \sqrt{-3}}{2} \quad [\text{From (1)}]$$

$$\text{If } y-1=0, y=1, \text{ and } x = \frac{-1 \pm \sqrt{-3}}{2}$$

Solving the equation,

$$xy + x + y = 0 \quad (3)$$

with (1), let $xy = a$ and $x + y = b$. Then equations (1) and (3) become

$$b^2 + b - 2a = 1,$$

$$a + b = 0,$$

whence

$$a = \frac{3 \mp \sqrt{13}}{2}, \quad b = \frac{-3 \pm \sqrt{13}}{2}$$

Solving the two pairs of simultaneous equations:

$$xy = \frac{3 \mp \sqrt{13}}{2},$$

$$x + y = \frac{-3 \pm \sqrt{13}}{2},$$

we obtain the remaining four solutions, namely,

$$x = \frac{\sqrt{13} - 3 \pm \sqrt{2}(\sqrt{13} - 1)}{4}, \quad y = \frac{\sqrt{13} - 3 \mp \sqrt{2}(\sqrt{13} - 1)}{4}.$$

$$x = \frac{-3 - \sqrt{13} \mp \sqrt{-2(\sqrt{13}+1)}}{4}, y = \frac{-3 - \sqrt{13} \pm \sqrt{-2(\sqrt{13}+1)}}{4}.$$

497. Proposed by Norman Anning, Chilliwick, B. C.

Solve in positive integers,

$$x^2 + y^2 = 31^2 + l^2 = 32^2 + m^2 = 33^2 + n^2. \dots\dots\dots (1)$$

I. Solution by Earl G. Baird, Greenville, Ill.

Since x and y are positive integers, l^2 , m^2 , and n^2 are positive integers of which only the positive roots are to be considered.

From (1) we have

$$\left. \begin{array}{l} l^2 = 63 + m^2, \\ m^2 = 65 + n^2. \end{array} \right\} \dots\dots\dots (2)$$

Let $l = m + k$ ($k = \text{any constant}$).

Then

$$l^2 = m^2 + 2mk + k^2 = m^2 + 63,$$

whence

$$m = \frac{63 - k^2}{2k}.$$

Since m is a positive integer and $l > m$, k is positive and odd and a factor of 63 and $1 \leq k \leq 7$. Therefore, $k = 3$ or 7 (1 is eliminated by trial), and $m = 9$ or 1.

But from (2) $m \neq 1$. $\therefore k \neq 7$. Hence, $k = 3$, $m = 9$; also $n = 4$, $l = 12$, and

$$x^2 + y^2 = 1105,$$

From this equation it is seen that all values of x and y are interchangeable, neither can be greater than 33, and they cannot both be ≤ 24 or ≥ 23 . By trial we soon obtain the pair of values, 23 and 24.

II. Solution by Mabel G. Burdick, Stapleton, N. Y.

$$32^2 - 31^2 = l^2 - m^2,$$

$$33^2 - 31^2 = l^2 - n^2,$$

whence

$$63 = (l+m)(l-m),$$

$$128 = (l+n)(l-n).$$

The only integral values satisfying these equations are $l = 12$, $m = 9$, $n = 4$.

The original equation becomes $x^2 + y^2 = 1105$.

The only other integral values satisfying this equation are 23 and 24.

Therefore, the single set of values is $x = 23$, $y = 24$, $l = 12$, $m = 9$, $n = 4$.

Geometry.

498. Proposed by E. R. Vanderhoof, Denver, Col.

Given the center and radius of a circle to find the side of the inscribed square by means of the compass alone.

I. Solution by Norman Anning, Chilliwick, B. C.; Earl G. Baird, Greenville, Ill.; A. E. Breece, Cincinnati, O.; J. S. Brown, San Marcos, Tex.; Mabel G. Burdick, Stapleton, N. Y.; J. H. Damon and L. W. Williams, Champaign, Ill.; C. E. Githens, Wheeling, W. Va.; L. E. A. Ling, La Grange, Ill.

Given r to construct $r\sqrt{2}$.

By "stepping" from a chosen point A, find the remaining vertices B, C, D, E, and F of an inscribed hexagon.

About A describe a circle with AC as radius.

About D describe a circle with DB as radius.

The circles will intersect because

$$AC + DB < AD < AC + DB.$$

The distance from the center of the given circle to either point of intersection is the required side of the inscribed square.

Proof. Let P be the point of intersection and O the center of the circle. Then $AP = DP = r\sqrt{3}$ and PO is $\perp AD$

$$PO = \sqrt{AP^2 - AO^2} = r\sqrt{3 - 1} = r\sqrt{2}.$$

II. *Solution by Frank C. Gegenheimer, Marion, Ohio.*

Given: Circle O with radius $OB = r$.

Required: To find side of inscribed square with compasses alone.

Construction: Apply OB to circle and find A and B, the extremities of diameter AB.

With A and B as centers and radius OB, draw semicircles, locating points C and D.

With C and D as centers and radius $CB = DA$, draw arcs intersecting in E.

With C and D as centers and radius OE, draw arcs intersecting in F, the mid-point of \widehat{AB} .

BF is the required side.

Proof: Assume the problem solved with F the mid-point of \widehat{AB} , and $CE = DE = CB = AD = 3r$.

$$\overline{OE}^2 = \overline{CE}^2 - \overline{OC}^2 = (3r)^2 - (2r)^2 = 5r^2.$$

$$\overline{CF}^2 = \overline{OF}^2 + \overline{OC}^2 = r^2 + (2r)^2 = 5r^2.$$

$$\therefore OE = CF.$$

Hence, the construction.

III. *Solution by Nelson L. Roray, Metuchen, N. J.*

From A, any point on the given circumference, with radius equal to given radius R, lay off in succession on circumference arcs AB, BC, and CD. A and D are end points of diameter of given circle.

With D as center and radius equal to R, describe arc EF without the circle.

With C as center and radius equal to AC, describe arc cutting EF at G.

With any point as center and radius equal to AC, draw a circle. On this circumference lay off as above arcs $A'B'$, $B'C'$, and $C'D'$ with AC as radius. From A' and radius equal to BG lay off arc $A'G'$.

Then with $D'G'$ as radius and G as center, describe an arc cutting given circle at P and P'. The points A, P, D, and P' are the vertices of the required square.

Proof: Since $CG = R\sqrt{3}$, $DG = R$, and $DC = R$, $\angle CDG = 120^\circ$.

$\therefore A, O, D, G$ are colinear.

$BG = R\sqrt{7}$ (law of cosines).

$A'D' = 2R\sqrt{3}$.

$\therefore D'G' = R\sqrt{5}$ (theorem of Pythagoras).

Since $OP = R$, $OG = 2R$, and $BG = R\sqrt{5}$,

$\angle GOP =$ a right angle.

499. *Proposed by R. M. Mathews, Riverside, Cal.*

Through the edges of a trihedral angle planes are passed orthogonal to the opposite faces. Prove the planes coaxial.

Solution by Mabel G. Burdick, Stapleton, N. Y.

In trihedral angle $V\text{-}XYZ$, planes through VX and VZ , orthogonal to opposite faces, intersect in a line, and at O , any point in this line, pass a plane perpendicular to VO , intersecting edges VX , VY and VZ in A , B , C , respectively. Let the orthogonal planes through VX and VZ intersect BC in A' and AB in C' , respectively.

Then, since $VO \perp$ plane ABC , plane $VCC' \perp$ plane ABC . Being also \perp plane VAB , plane $VCC' \perp$ their line of intersection, AB , and CC' is an altitude of $\triangle ABC$. Likewise, AA' is an altitude of $\triangle ABC$.

Let plane through VB and VO intersect AC in B' , BB' , passing through O , is also an altitude of $\triangle ABC$. Since plane $VBB' \perp$ plane ABC and $AC \perp BB'$, $AC \perp$ plane VBB' ; then plane $VAC \perp$ plane VBB' ; that is plane VBB' is orthogonal to the third face from the opposite edge, and these planes are coaxial.

500. For lack of space the solutions to this problem are omitted and will be published in April.—Editor.

CREDIT FOR SOLUTIONS.

- 482, 483, 484, 485, 486, 488, 489, 490. Yeh-Chi Sun. (8)
 493. R. M. Mathews.
 494. F. C. Asbury.
 495. Ralph Corley, Ned Guthrie. (2)
 496. Felix A. Ciampi, Nelson L. Roray, one incorrect solution. (3)
 497. Earl G. Baird, Mabel G. Burdick, C. E. Githens, Nelson L. Roray. (4)
 498. Norman Anning, Earl G. Baird, A. E. Breece (2), J. S. Brown, Mabel G. Burdick, J. H. Damon, L. W. Williams, C. E. Githens, F. C. Gegenheimer, L. E. A. Ling, Nelson L. Roray. (11)
 499. J. S. Brown, Mabel G. Burdick, one incorrect solution. (3)
 500. Norman Anning, Earl G. Baird, J. S. Brown, W. W. Gorsline, E. Kesner, Murray J. Leventhal, R. M. Mathews, F. V. Rayl, Nelson L. Roray (3), E. H. Worthington. (12)
 45 solutions.

PROBLEMS FOR SOLUTION.

Algebra.

511. *Proposed by Daniel Kreth, Wellman, Iowa.*
 In what time would a debt be extinguished by paying the annual interest at 6% if interest be allowed on the payments at the same rate?
 512. *Proposed by N. P. Pandya, Khatri Pole, Bajwada, Baroda, India.*
 The logarithms (Briggian) of two numbers differ by 1.4238 and the numbers themselves by 3856. Find the numbers.

Geometry.

513. *Proposed by Murray J. Leventhal, New York City.*
 Given a point, a straight line, and a circle, to construct a circle having its center in the given line, passing through the given point, and cutting off on the given circle an arc whose subtending chord is equal to a given line segment.
 514. *Proposed by Yeh-Chi Sun, Peking, China.*
 Having given the lengths of the three angle bisectors of a triangle, required to construct the triangle.
 515. *Proposed by L. E. Lunn, Heron Lake, Minn.*
 Prove the following theorem: The planes perpendicular to the faces of a trihedral angle and intersecting those faces along the bisectors of the face angles are coaxial.

A Request.

We respectfully request that all contributors read and heed the following rules:

1. Introduce each solution submitted as follows: 999. Solution by (Your name and address). It is not necessary to copy the words of the problem. The number is sufficient.
2. Write only on one side of the paper.
3. If two or more short solutions are written on the same page, leave ample space between problems and don't fail to observe Rule 1.
4. Do not make solution dependent on a submitted figure, e. g., do not write "line AB" with no previous verbal definition of A and B, expecting a reader to find the line and points on a figure. It is not always convenient to publish the figure.
5. Where a figure is necessary, draw the same accurately and to scale on a separate sheet of paper in jet black or India ink.
6. Introduce each problem proposed as follows: Proposed by (Your name and address). When more than one proposed problem is written on a page, leave ample space between problems that they may be clipped.

SCIENCE QUESTIONS.

Conducted by FRANKLIN T. JONES.

University School, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.

Please send examination papers on any subject or from any source to the Editor of this department. He will reciprocate by sending you such collections of questions as may interest you and be at his disposal. Send your first term or mid-year examination papers now.

Questions and Problems for Solution.

254. *Proposed by W. T. Harlow, Portland, Ore.*

A block weighing 500 lbs. can just be supported on a rough inclined plane by a force of 194 lbs., or it can just support a weight of 400 lbs. suspended by a cord passing over a smooth pulley at the vertex. Find coefficient of friction and the inclination of the plane.

255. *Proposed by Ross Allen Baker, University of Minnesota.
(From a list for students in general chemistry.)*

Suppose 100cc. of H_2 were mixed thoroughly with 500cc. of Cl_2 and exploded, and the product cooled to the original temperature. What would be the total volume and of what would it consist?

The following list of questions in physics was given, June 14, 1916, for entrance to the Day School of Applied Science.

CARNEGIE INSTITUTE OF TECHNOLOGY.

Please answer questions numbered 256, 257, 258.

Answer ten questions.

1. A 100 gram mass starts from rest with two forces acting on it, 400 dynes due east and 300 dynes due north. How does it move? How far will it move in 10 seconds?

256. What power is developed by a force of 300 pounds moving with a velocity of 10 feet per second?

3. Does a body weigh more or less at the North Pole than at the equator? on a mountain than in a valley? Give reasons.

4. If the frequency of a certain tone is 300 vibrations per second, and the velocity of the sound in air is 1100 feet per second, what is its wave length?

5. Make a diagram showing the relation between the Fahrenheit and the centigrade scales of temperature.

257. A body, mass 100 grams, is heated to the temperature of steam, and is then dropped into a calorimeter containing 100 grams of water at 15 degrees C. The temperature rises to 25 degrees C. If the water equivalent of the calorimeter is 10 grams, what is the specific heat of the test piece?

7. Show how to construct the image formed by a convex mirror, and by a biconvex lens.

258. What is the candle power of a source of light which gives a photometric balance when it is three times as far away from the photometer screen as a 16 candle power standard?

9. Two voltaic cells, each of 1.4 volts electromotive force, and 1 ohm resistance are connected in series with an ammeter of 3 ohms and a lamp of 5 ohms resistance. What is the ammeter reading?

10. Describe three experiments which illustrate the mutual action of magnets and electric currents or circuits.

11. Describe one of the experiments that you performed in the laboratory and give any conclusions that you reached.

Please name the textbook and the laboratory manual that you studied.

The following list of examination questions represents the unusual subject whose loss from our school curriculum is to be lamented.

ASTRONOMY, SEPTEMBER 17, 1915, BROWN UNIVERSITY.

Omit one of the following:

1. Explain one method of determining the latitude of a place.
2. Explain the precession of the equinoxes.
3. Give a brief account of the system of Saturn.
4. State some theory in explanation of the maintenance of the heat of the sun.
5. Explain the difference between the mean solar and the sidereal day.
6. What is remarkable about the moon's rotation? Explain her librations.
7. Name the principal planets in the order of their distance from the sun. Name them in the order of their size.
8. Define hour-circle, azimuth declination, hour-angle, and right ascension.
9. Explain the phases of the moon.
10. What is meant by the "proper motions" of the stars?

Solutions and Answers.

235. *Proposed and solved by R. W. Boreman, Parkersburg, W. Va.*

A solution of $Mg(OH)_2$ has 3.0009 parts of the $Mg(OH)_2$ in 100 parts of water. What is the maximum concentration of OH ion that can be present in .1 molar $Mg SO_4$ solution that is 37% ionized?

Solution. Solubility of $Mg(OH)_2$ is .0009 parts per 100 cc. or .009 grams per liter. Its molar solubility is therefore $.009 \div 58 = .00015$. Its solubility product is $.00015 \times (.0003)^2 = 1.3 \times 10^{-11}$. If .1 molar $MgSO_4$ solution is 37% ionized, then the concentration of Mg^{++} in this solution is 37% of .1 = .037. The greatest concentration the hydroxyl ion can attain in a solution having a Mg^{++} concentration of .037 is given by the relation, $.037 \times (OH^-)^2 = 1.3 \times 10^{-11}$, or $(OH^-) = \sqrt{3 \times 10^{-10}}$, or 1.4×10^{-5} .

243. *Proposed by J. P. Drake, Emporia, Kan.*

A ladder 30 ft. long and weighing 100 lbs. rests against a wall at an angle with the wall of 45° . Center of gravity of the ladder is $\frac{1}{2}$ up from the base. Coef. of friction with ground = .6; with the wall it is .3. How far up can a man who weighs 200 lbs. climb before the ladder will begin to slip?

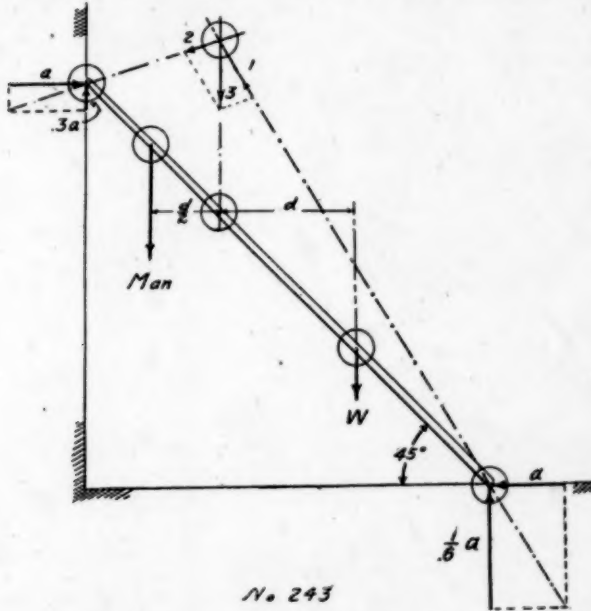
The problem admits of very neat graphical solution—based, of course, on the principle that three forces in equilibrium are concurrent.

The three forces are:

1. The ground reaction.
2. The wall reaction.
3. The total load on the ladder.

The actual value of force a was taken arbitrarily and then scaled after M (man) had been located.

This method of solving such problems is very simple, and it is too much neglected in both high school and college mechanics teaching.



Solution by Hallam H. Anderson, Berkeley, Cal.

Rewording problem for general case,

"A ladder l ft. long and weighing w lbs. rests against a wall at an angle of α° . Center gravity of the ladder is n l distant from base. Coef. of friction with ground $= f_2$; with wall it is f_1 . How far up can a man who weighs M lbs. climb before the ladder will begin to slip? Call this distance x ."

Let a be normal reaction of wall. Then $f_1 a$ will be vertical or tangential reaction of wall, also a will equal horizontal or tangential reaction of

ground, and $\frac{1}{f_2} a$ will be normal reaction of ground.

Taking moments around base:

$$f_1 a \cdot l \cos \alpha + a \cdot l \sin \alpha = W \cdot n \cos \alpha + M \cdot x \cos \alpha.$$

$$x = \frac{a \cdot l (f_1 \cos \alpha + \sin \alpha) - W \cdot n \cos \alpha}{M \cos \alpha}.$$

From equilibrium considerations

$$M + W = f_1 a + \frac{1}{f_2} a.$$

$$a = \frac{M+W}{f_1 + \frac{1}{f_2}}$$

$$l \left(\frac{M+W}{f_1 + \frac{1}{f_2}} \right) (f_1 \cos \alpha + \sin \alpha) - W \cdot n l \cos \alpha$$

Substituting, $x = \frac{\quad}{M \cos \alpha}$.

For the particular case where $\alpha = 45^\circ$,

$$x = \frac{l \left(\frac{M+W}{f_1 + \frac{1}{f_2}} \right) (f_1 + 1) - W \cdot n l}{M}$$

Given $l = 30$ ft., $W = 100$, $\alpha = 45^\circ$, $n = \frac{1}{3}$, $f_1 = .3$, $f_2 = .6$, then $x = 24.83$ ft.

Also solved by Loyd C. Elliott, Phoenix, Ariz., and by Earl C. Bennett, C. D. Wheelock, Paul H. Kerrick, R. Ross Keith, L. Achenboch, John Shell, Walter Kidder, H. Danson, P. E. Simpson, R. O. Ford and Chas. D. Samuels of Riverside Junior College, Riverside, Cal.

245. *Chemical Annual*, No. 55. Answers are (a) 35,647.5 lbs., (b) 43,216.2 lbs.

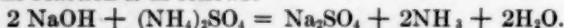
247. *From a College Board Examination.*

Solution by Harry C. Redeker, Rupert Electric High School, Rupert, Idaho.

How many liters of ammonia gas, measured under standard conditions, can be obtained when 20 gms. of sodium hydroxide react with an excess of ammonium sulphate? (Na = 23, O = 16, H = 1, N = 14, S = 32.)

A gram molecular weight of a compound means its molecular weight expressed in grams. A gram molecular weight of a gas at standard conditions occupies 22.4 liters of space.

The reaction is as follows:



By the above it will be noticed that two molecules of sodium hydroxide will liberate a like number of ammonia molecules, or the ratio is as 1 is to 1.

The molecular weight of sodium hydroxide is 40. Since 20 grams of the above are used, this is equal to one-half the gram molecular weight of the substance, and therefore one-half a gram molecular weight of ammonia gas will be liberated. Hence the latter will occupy 11.2 liters of space at standard conditions.

You may be interested in knowing that here at Rupert we do everything electrically, and that in the science laboratories this is true. All work in chemistry except bending glass tubing and producing of reducing and flame tests is done by means of electrical appliance.

RESEARCH IN PHYSICS.

Conducted by Homer L. Dodge.

State University of Iowa, Iowa City.

Representing the American Physical Society.

Nearly all the results of modern research are published in short technical articles, of interest only to those who are working in the same or allied fields. Occasionally, some man, well versed in the details of subject, will summarize the work of a given field in a book. If it is well written by one who combines with thorough knowledge of the subject the imagination necessary to view the work in its proper perspective and to give it a setting among more familiar realities, the book is welcomed by all students of physics. Unfortunately, there are not many such books, but when one does appear this department will call attention to the fact.

X-RAYS AND THEIR APPLICATION TO THE STUDY OF CRYSTAL STRUCTURE.

Ever since the discovery of X-rays by Rontgen in 1895, their nature has been the subject of the keenest investigation. In many respects the rays resemble light. They move in straight lines and cast sharp shadows, they traverse space without any obvious transference or intervention of matter, they act on a photographic plate, excite certain materials to phosphorescence, and can bring about the ionization of a gas. In other respects the rays have seemed to differ from light. The mirrors, prisms, and lenses which deflect light have no such action on X-rays, diffraction gratings do not diffract them, and neither double refraction nor polarization is produced by the action of crystals.

If the velocity of X-rays could have been shown without question to have been the same as that of light, it would have been an important bit of evidence. The results of certain work pointed in this direction, and a sort of polarization was found which was strong evidence of a similarity of the nature of light and X-rays, but it was far from conclusive.

Such was the state of uncertainty when in 1912 Dr. Laue of the University of Zurich conceived the idea of making use of crystals for the study of X-rays. Through the application of this idea by himself and others, rapid advances have been made in discovering the nature of the rays and also in interpreting the structure of the crystals themselves. It has now been conclusively proved that light and X-rays are identical in nature, and that this identity is even closer than had been thought in that it precludes one from ascribing difference in character to anything other than mere difference in wave length.

In respect to crystals, it has proved to be a new and powerful means of investigating their structure. Instead of guessing the internal arrangement of the atoms from the outward form assumed by the crystal, one is now able to measure the actual distances from atom to atom, and to draw a diagram as if one were making a plan of a building. The use of crystals in the study of X-rays is somewhat analogous to the use of the diffraction grating in the study of light.

This instrument, as is well known, consists of an arrangement of parallel and equidistant straight lines ruled in great numbers on a glass or metal surface. When light falls upon the grating, each line acts as if it were itself a source of light. The production of the spectrum depends upon the fact that in any particular direction there is destructive interference for all wave lengths save one. This wave length is reinforced by the light from every line and is as a result very strong.

The action of a crystal with respect to X-rays is quite analogous

except that in this instance the reflections occur from points rather than lines, and throughout the body of the crystal instead of at a surface. In fact, the mechanism is not at all simple, but its principle can be made quite clear by an illustration which makes up in aptness what it lacks in elegance.

Everyone who has ridden or walked past a cornfield, regularly planted with a checkrow, when the corn was not too high, has noticed how he is able to look across the field of corn and see the hills fall into definite rows, not only in the two directions intended for the sake of ease of cultivation, but in many other directions as well. In fact, if the field is very well planted, he can look across it in as many as fifteen or seventeen different directions and see the hills lined up in rows. The point to which we wish to call particular attention is that these rows are all perfectly regular, and the rows in any particular direction are equally spaced from each other. However, the actual distance between the rows will depend upon the direction in which they are taken.

Let us imagine that each hill of corn is able to reflect sound waves, and that an orchestra is playing near by. To correspond to the fact that the detector of the X-rays is at a distance from the crystal which is large in comparison to the dimensions of the crystal, we must imagine that our field is of only a few acres extent and that the listener is at least a mile away. If these conditions are fulfilled and the orchestra begins to play, each hill of corn will send out its reflected series of waves. On the whole, these waves will interfere, but if in a certain direction (at right angles to the rows) the spacing of the rows is at just the right distance to correspond to the wave length of a particular note, then in that direction the sound from every reflecting center will be in phase and the note will have the maximum possible intensity. An observer in this direction would hear this note sharp and clear, but would hear practically nothing of the rest. In just as many directions as there were ways of arranging the rows, particular wave lengths would be reinforced. Thus a person walking around the field would for the most part hear but little (reflected) sound, but at certain points lying in the proper directions would hear particular notes, or wave lengths, very strongly.

Suppose that one were ignorant of the pattern in which a field were planted, but were allowed to direct upon it sound waves of known frequencies and to determine the directions in which the waves were reflected with strong intensity. It is not hard to imagine that one might be able to tell from these facts the exact arrangement and spacing of the hills, provided they followed a fairly simple plan. This is the problem of the student of crystal structure, to determine the arrangement of the atoms from the nature and direction of the X-rays reflected from the crystal. Infinitely harder is it than the illustration that we have used, for the atoms of a crystal are not confined to a plane but fill a space. Not only do they fall into rows along the three principal directions, but along diagonals as well.

Our illustration brings out another point of fundamental importance in the construction of gratings and the use of crystals in the study of X-rays. A little consideration of the manner in which the sound waves, reflected from the field of corn, are able to reinforce each other in certain directions will convince one that the spacing of the rows of corn must be of the same order of magnitude as the wave length of the sound. Likewise in a grating it is necessary to have the ruled lines separated by spaces of about the wave length of the light to be measured. For example, sodium light, which has a wave length of .0000589 cm., is diffracted through about 24 degrees by a grating which has 7,000 lines to the centi-

meter, i. e., a spacing of .000143 cm. Now the X-rays have wave lengths in the neighborhood of 10^{-8} cm. or 10^{-9} cm., or about ten thousand times smaller than the waves of sodium light. To construct a grating of appropriate spacings is unthinkable, because the spacings would need to be of the order of the distances between the molecules of a solid.

The problem of a suitable grating was solved when the idea of using a crystal was conceived. The orderly arrangement of the atoms of a crystal is a proper "grating" for X-rays. The spacing of the atoms is of the right order of magnitude. Although, as has been explained, the problem is not so simple as in the case of a grating, the attack has been successful. Not only has the nature of X-rays been determined and much learned regarding the structure of crystals, but facts of far-reaching theoretical importance have come to light.

Prominent in this work have been Prof. W. H. Bragg and his son, W. L. Bragg, who have simplified the methods of analysis and devised a very practical form of X-ray spectrometer. It consists essentially of a source of X-rays, a rotating stand for the crystal, and a detector of X-rays which can be made to revolve around the crystal through a large angle. An ionization chamber was originally used as a detector, but may be replaced by a photographic plate. In using the spectrometer, either the crystal or the detector may be rotated. In either case the relative position of the two is altered, and the directions in which strong reflections occur easily determined. By placing the crystal with its various faces exposed to the X-rays in turn, one may study the reflections from the various sets of planes.

Anything approaching an adequate discussion of the results of this work is impossible in the space available. It will, however, be well to call attention to some of the most striking of the new discoveries and recall some of the more familiar facts concerning X-rays. X-rays are produced by bombarding metal plates, usually of platinum or tungsten, by electrons to which a high velocity has been imparted by the electromotive force of an induction coil. The process can be effectively carried out only in a so-called vacuum tube. The cathode is connected to the negative terminal of the coil and becomes the origin of the fast moving electrons or "cathode rays." The conditions of working depend greatly upon the amount of gas left in the bulb. If there is too much, it is found that the supply of electrons is plentiful, so that it is easy to pass current through the tube, and the electromotive force is driven to high values. The speed of the electron is slow, and the X-rays which they produce are found to have little penetrating power. The bulb is said to be soft.

On the other hand, if the vacuum is too high, and it generally tends to rise as the bulb is used, the supply of electrons falls off. The electromotive force then rises, the electrons acquire greater speeds and give rise to more penetrating X-rays. The bulb is said to be "hard."

A pencil of X-rays issuing from an X-ray bulb is generally of very mixed composition, i. e., of many wave lengths. Nevertheless, it is possible to obtain pencils of X-rays which may be considered to be homogeneous. It has been known for some time that every substance under the proper stimulus emitted an X-radiation which was homogeneous and characteristic of that substance. In certain cases a substance could emit two homogeneous radiations of different quality. The necessary stimulus required to make a substance emit its characteristic X-rays is provided by irradiating the substance in question with X-rays of a penetrating power which must be a little greater than that of the rays which are to be produced. It has also been shown that the characteristic rays

are excited if the substance is made the anticathode of an X-ray bulb and bombarded by cathode rays of sufficient velocity. The substance of the bombarded anticathode contributes its characteristic rays to the general stream, and the spectrometer analyzes the radiations into a more or less continuous spectrum, from which certain homogeneous pencils of definite wave length stand out with greater or less clearness. The importance of these facts is brought home when one realizes that any substance possesses a characteristic X-ray spectrum in the same way as it has a characteristic spectrum in the visible wave lengths of light.

Let us now turn to the other side of the problem, for not only has the crystal made possible a study of the X-rays, but the X-rays have been the means to an understanding of the structure of the crystal. We have seen by analogy how it is that a crystal upon which is directed a stream of X-rays will when rotated throw out successively, in different directions, strong pencils of rays. It is also evident that a knowledge of the directions of these pencils and of their wave lengths would furnish the key to the arrangement of the atoms in the crystal. A comparison of the spectra obtained from sodium chloride, NaCl, potassium chloride, KCl, potassium bromide, KBr, and potassium iodide, KI, gave the first clue regarding the spacing of the atoms and showed the "rock salt series" to be made up of atoms arranged according to a cubical system. Of the eight corners of any particular cube, four are occupied by the metallic atoms and the other four by the halogen atoms, the arrangement being such that it repeats itself in every direction throughout the crystal.

The discovery of the arrangement of the atoms in one crystal was necessary before any progress could be made with actual measurements. In the dual study of X-rays and crystals, each by means of the other, some starting point was necessary. Either the wave length of the X-rays had to be known, or else the arrangement and width of the spacing of some crystal. After the structure of the rock salt series was known, it was possible from certain other considerations to compute the distance between the successive planes, which in rock salt was found to be 2.8×10^{-8} cm. With this as a starting point, exact measurements of wave length and atomic spacing could be made.

Many other crystals than those mentioned have been studied. One of the most interesting is the diamond, which was found to have a structure of such a form that each atom is at the center of a tetrahedron at each apex of which are located other carbon atoms. It would be hard for one to conceive of a more firmly braced structure than this.

In this brief account we have tried to give a little idea of the work of those who have made the crystal their slave and forced it to reveal not only the secret of the X-rays but its own as well. Waves so small that a train of a thousand million would be but an inch in length are studied with almost the same ease as are the waves of light. Each individual atom is made to respond to the questions of the investigator, and the simultaneous response of millions of them is so loud and clear that he can map their positions as the engineer does the houses of a town. And it would take a million million million of them to fill the head of a pin!

We have followed very closely the volume on *X-Rays and Crystal Structure*, by Prof. W. H. Bragg, of the University of London, and his son, W. L. Bragg.¹ A great deal of the recent progress has been due to the work of these two men. The book which they have written is one of the kind referred to in the paragraph at the head of this department. The reader is led from simple familiar fields along paths which he can easily follow, until he finds himself right in the maze of current investigation and thought. This brief review can only suggest the really important parts, those dealing with the application of the knowledge of X-rays to some of the most knotty problems of modern physics, such as that of radiation, and the other most fascinating chapters in which the details of the investigations of the structure of crystals are explained.

¹ The Macmillan Co., 66 Fifth Ave., New York. Price \$2.25.

REPORT OF SECTION MEETINGS OF THE C. A. OF S. AND
M. T. UNIVERSITY CHICAGO OF MEETING.

MINUTES OF THE CHEMISTRY SECTION:

The meeting was called to order by the Chairman, S. C. Engle.

Mr. Parsons of the Central Scientific Company extended an invitation to the members of the section to visit the Central Scientific Company's plant the following afternoon.

The Chairman called attention to the various exhibits that were on display in the different buildings, and especially to the chemistry display under the management of Miss Caplin of the West High School, Minneapolis. Catalogues of the chemistry display could be had at the desk.

The following were appointed on the Nominating Committee: O. E. Bates, G. C. Ashman, and Frances Church.

The Committee on Resolutions was composed of the following: F. H. Currens, C. W. Botkin, and H. M. Mess.

In taking up the program for the afternoon, the Chairman said the object had been to get something practical in the program, something to take home and make use of in the classroom, and he suggested that the section be very liberal in the discussions which were to follow the papers.

Since these papers are given in full in the *Proceedings*, no abstracts of them are included in these minutes.

T. B. Gullum of East High School, Columbus, Ohio, gave a paper on "Text Approach of Teaching Chemistry."

H. S. Doolittle of Ann Arbor High School, who was to speak on the "Laboratory Approach of Teaching Chemistry," was unable to be present. He had planned to speak from notes so had no prepared paper to send.

C. W. Eastman of Central High School, St. Paul, Minn., was also unable to be present. He sent his paper, "Text Approach of Teaching Chemistry," which was read by Mr. Wade of the Shortridge High School. Mr. Wade prefaced the reading by saying that he was on the other side of the question.

A. C. Norris, Supervisor of Chemistry, Rockford, Ill., read a paper on "How I Should Teach Chemistry Were There no Textbooks in the Hands of My Pupils."

Discussion of the papers was next on the program.

Blanks indicate that the Secretary failed to get the names of the speakers. The first paper discussed was that of the last speaker, and the discussion was mainly in the form of questions and answers.

Mr. Norris was asked if he actually taught chemistry without a textbook. He replied, "No, my subject was 'How I Should Teach Chemistry Were There no Textbooks in the Hands of My Pupils.' My pupils think I do not use the text enough. I try to ask questions so that if they have read the text they can answer the questions. The phase of chemistry that we emphasize is having the pupils understand the chemistry that they will meet with in life. Occasionally there is one from our number of pupils at the University who fails in his college chemistry, but at the same time there are forty or fifty who do not fail. We are not trying to meet the college requirement."

When asked if they gave extra credit for the outside work which he mentioned in his paper Mr. Norris said, "Yes, and we have a minimum requirement as to quality as well as quantity. A boy may complete our high school in three and one-half years taking four subjects by doing a superior quality of work or he may be required to take four and one-half

years carrying four subjects because he does not receive a grade above seventy-nine per cent."

Discussion of points in Mr. Eastman's paper:

One member asked for some expression concerning Mr. Eastman's method of arbitration in grades. None seemed to be in the habit of submitting records to pupils for examinations. The following are some of the opinions expressed: "We could not take the time." "I favor arbitration but do not submit records." "We do not attempt to grade closer than five per cent and we try to substitute a desire for the study of the subject rather than for the grades." Mr. _____ told of his experience with both methods and said he found it more satisfactory when the teacher did not attempt to grade within five per cent. "A desire for arbitration always comes from the poor pupil."

Mr. _____ said "We have an 'emergency book.' Each pupil at the beginning of the year provides himself with a five-cent notebook. Once or twice a week we take the last fifteen minutes for written work in these books. Each pupil puts down the one or more points which he regards as of the most importance in the lesson. If, when the grades are given out, any pupil is dissatisfied, these 'emergency books' are consulted. We do not have any calls for arbitrations on grades."

Mr. Engle said that he found when a pupil responded to a question, though he answered incorrectly, he thought he had made a recitation and usually he needed something more to impress him with his failure than just the correct answer of another pupil.

Mr. _____ said, "The good student gets a fair deal. In our school, he may take an examination if he is not satisfied with his grade, but his final grade is that which he gets in this examination."

Discussion of the laboratory approach:

Mr. Wade thought there was some difference in what was termed laboratory approach and what textbook approach. As a specific example, in taking up the study of chlorine through hydrochloric acid, he would first quiz the pupils on what hydrochloric acid would furnish; how to get rid of the hydrogen; different methods of oxidation; specific oxidizing agents. He would then give some guidance for the laboratory work, but he would *not* call this textbook approach. Finally, after the laboratory work, he would have the pupils go to the text to get an orderly arrangement of the subject matter, and by this repetition to fix it in the mind.

Mr. Smith, Harrison Technical High, thought the laboratory work should come first. He said, "Learn directly from nature. Which is the method the student is going to use in after life? Will the student by the textbook approach learn to observe? Pupils will see what the text tells because they will know what they ought to see. From the laboratory work, they get practice in reasoning or attempts at reasoning. Is textbook work training or parroting? In the laboratory, pupils work with materials, develop initiative. It is no crime to make mistakes in work, but it is a crime to do no work. If pupils learn from text, they will have to change on leaving school, to the other method of learning, so why begin with it? The question is: Which method will give the better training for life work? There is no question in my mind which is the better."

Miss Caplin was asked to talk on the chemistry exhibit which she had in charge. The idea of such an exhibit was suggested to her by her visit to the Deutsches Museum of Munich. She said the present exhibit was a hurried attempt to get together some of the material which the chemistry teachers had at hand to illustrate their work. The exhibit consisted

of about two hundred catalogued pieces and was both interesting and instructive. There were a number of clever devices which could be used to advantage in the laboratory.

In response to Mr. Roecker's suggestion that chemistry exhibits be made a permanent feature of the section, it was moved and seconded that a committee of three be appointed by the Chair to approve and report on new apparatus and materials, and to have in charge the chemical exhibit; carried.

The Chair appointed Miss Jessie Caplin, West High School, Minneapolis, Minn., R. W. Ladd, Gary, Ind., and Ray McClellen, High School, Michigan City, Ind.

The meeting then adjourned to the East lecture hall, which was equipped with a stereopticon, where Mr. Ladd gave a paper on "Vitalizing Chemistry." It was illustrated by views of apparatus made and used by his pupils in their study of industrial processes.

Time did not permit a discussion.

The meeting adjourned until 10 a. m. the next day, December 2.

The meeting was called to order by the Chairman.

Frederick C. Irwin, who was to have had the first paper, was called to New York. B. J. Rivett of Detroit, Mich., took his place and read a paper on "The Commercial and Industrial Demands of the Chemistry of Tomorrow." By way of introduction, he said that he had visited more than fifty industrial plants, and that the information given in the chemistry courses in the Detroit schools was based upon actual industrial processes. He pointed out the increased interest shown in the study of chemistry and the increased opportunities for the worker in the field of chemistry. His paper is given in full in the *Proceedings*.

Discussion:

Mr. Rivett was asked of what the advanced course in chemistry of the Central High of Detroit consisted.

The answer was, "We are using Alexander Smith's college text, and the laboratory work is about the same as is given in the university. Many of the students are pre-medics. After this course, we have qualitative the first half of the year and quantitative the last. In the Case School they have one year of general chemistry, then qualitative analysis followed by quantitative."

Mr. Wade asked concerning the effect of segregating the bright pupils, which was mentioned in Mr. Rivett's paper. Was it not bad for the average pupil? Mr. Engle wanted to know how the poor section got along.

Mr. Rivett's answer was as follows: "This segregation gives no trouble. All take the same work the first semester; they lay a foundation for their work; study the elements, acids, bases, and salts. The second semester, twenty-eight of the most capable, all boys, are chosen out of a class of one hundred. The remaining boys and the girls are segregated; the girls are given a course in the chemistry of domestic science, and the boys a course in industrial application of chemistry."

Mr. Wade said that, according to statistics, the number in Mr. Rivett's school taking industrial courses in chemistry could not find employment in that line. He asked what the boys who take these special courses do. Mr. Wade found that perhaps six per cent of his pupils who take chemistry obtain employment in that or related lines, but that they do not stay; they go to college. Most of them haven't the makings of chemists. His idea has been to teach appreciation of technical processes rather than make chemists.

Mr. Rivett replied: "It is not our business to train chemists. If the

high school pupil wants to be a chemist he must go to the university. We have a technical course that leads into the *trades*. It aids men working in industries. The Case Technical School is not training *chemists*. Boys from our schools get positions doing mechanical work in chemical laboratories, that is a part of their education, but many never become chemists nor never go to college."

Dr. Hessler said the most successful of his former chemistry students were those who had the ability to manage an industry. Their training in chemistry had given them a broad appreciation of technical processes and an ability to judge results.

Charles J. Pieper of the University High School, Chicago, gave a "Review of Laboratory Manuals of Chemistry." Seventeen manuals were reviewed.

Frank B. Wade, head of the Department of Chemistry, Shortridge High School, Indianapolis, read a paper on "Use of Loose-Leaf Notebooks in Chemistry."

Both these papers are to appear in the *Proceedings*. Owing to a lack of time, the discussion of them had to be omitted.

A question concerning the advisability of the pupil's use of stencils in making illustrations of apparatus was asked. Some saw no objection to its use; others regarded stencils as useful tools comparable to the ruler and the T-square of the architect; others objected to the use of stencils since they did not permit a drawing to scale.

A copy of the report of the Committee on Correlation of Home Economics and Chemistry was filed with the Secretary. It is given in the *Proceedings*.

The following report of the Committee on Resolutions was read by Mr. Currens and the resolutions were adopted:

No. 1. Resolved, That we, as members of the Chemistry Section of the Central Association of Science and Mathematics Teachers, extend our hearty thanks to the University of Chicago and particularly to the Chemistry Department for their kindness in providing a building with the best of conveniences for the meetings of this section, and that a copy of this resolution be sent to Prof. Stieglitz, Director of the Kent Laboratory.

No. 2. Resolved, That we extend the thanks of this section to the officers of this year for the excellent program which they have prepared.

No. 3. Resolved, That the thanks of the section be given to each one who has presented a paper at this meeting, and to Miss Caplin for preparing the chemistry exhibit.

No. 4. Resolved, That we commend the special project or special problem plans discussed at this meeting as being very efficient aids to the teaching of chemistry.

J. G. CURRENS.
C. W. BOTKINS.
H. M. MESS.

The Committee on Nominations reported as follows:

For Chairman—S. Ralph Powers, Minn. University High School, Minneapolis, Minn.

For Vice-President—T. B. Gullum, East High School, Columbus, Ohio.

For Secretary—R. M. Ladd, Gary, Ind.

The report was accepted.

The meeting was adjourned for the afternoon trip to the Oil Refining Plant at Whiting, Ind.

FRANCES CHURCH,
Secretary.

Minutes of the Mathematics Section.

The Mathematics Section of the Central Association of Science and Mathematics Teachers held meetings on December 1 and 2, 1916, in Belfield Hall, the University of Chicago.

Friday Afternoon Session.

The first session opened at 1 o'clock, Friday afternoon, with the Chairman of the section, Prof. J. W. A. Young of the University of Chicago, presiding.

It was voted that the Chairman appoint a committee to nominate officers for the coming year, and the following were named: Charles Ammerman, St. Louis, Chairman; Clarence E. Comstock, Peoria; C. A. Petterson, Chicago.

Prof. E. J. Wilczynski of the University of Chicago gave an address on "The Fundamentals of Algebra," which was followed by an informal discussion.

The report of the Committee on Geometry was presented by its Chairman, E. R. Breslich, of the School of Education, the University of Chicago.

It was voted that the report of the committee be accepted and the committee discharged.

The report of the Committee on Publicity was presented by its Chairman, Miss Edith I. Atkin of Illinois State Normal University.

After discussion of the report, it was voted that a Publication Committee be appointed and that the Publicity Committee be enlarged according to the recommendations of the report, the details being left to the outgoing and the incoming Chairmen. It was voted that the section approve the third division of the report (recommending the establishment of a *Question and Answer Department* in SCHOOL SCIENCE AND MATHEMATICS), and that we express our hope that it will be put into operation.

The attendance at the Friday afternoon session was about 125.

Saturday Morning Session.

The Nominating Committee recommended the election of the following as officers of the section for the coming year:

Chairman—W. W. Hart, The University of Wisconsin.

Vice-Chairman—J. A. Fobey, Crane Technical High School, Chicago.

Secretary—Edith I. Atkin, Illinois State Normal University.

In presenting this report, the Chairman of the Nominating Committee pointed out that the committee had found it necessary to depart from the section's established custom of advancing the Vice-Chairman of the current year to the Chairmanship of the next year, on account of the projected extended absence of the present Vice-Chairman, Mr. Touton, from the territory of this Association; also that the present Secretary, Miss Gogle, who has served so efficiently for quite a number of years, was not re-nominated on account of her election to the Presidency of the Association.

It was voted that the report be accepted and the members elected to the offices named.

The Mathematical Association of America, which is undertaking a study of the whole field of mathematics and its status in the schools, has requested the Central Association to appoint a secondary school representative to cooperate. After discussion, the incoming Chairman was empowered to appoint the desired representative and also an advisory committee to work with him.

An address on "Modern Developments in Elementary Mathematics" was given by Prof. G. A. Miller of the University of Illinois.

The report of the Committee on Correlation was presented by its Chairman, Miss Edna Allen of Chicago, and that of the Committee on Vocational Mathematics by its Chairman, Prof. K. G. Smith of Iowa State College, Ames, Iowa. Members of the Association may obtain a complete report in mimeograph form of this report on application to the Chairman.

It was voted that both of these reports be accepted and the committee discharged.

A vote of thanks was passed to the two speakers and to the members of all the committees reporting at this meeting.

Mr. Cobb, Mathematical Editor of *SCHOOL SCIENCE AND MATHEMATICS*, stated that the *Question and Answer Department*, recommended by the section, would be established, and asked that questions (short and to the point) be sent to him.

The attendance at the Saturday session was about eighty.

Abstracts of the addresses, the reports of the committees, and summaries of the discussions will appear in the *Proceedings*.

MARIE GUGLE,
* Secretary.

Minutes of the Physics Section.

The meeting was called to order by the Chairman, Earle R. Glenn.

The first paper was by T. R. Wilkins, University High School, Chicago. It was a presentation of "The Architecture of High School Physics," illustrated with slides showing a number of the best laboratories of large, medium sized, and small high schools.

The second paper was given by Prof. G. W. Stewart of the University of Iowa. This paper, entitled, "Physics in the High Schools of Tomorrow," was a plea for a study by the Physics Section of the content of the high school course in physics.

The third paper, given by Prof. R. D. Carmichael of the University of Illinois, was a discussion of "The Relation of Mathematics and Physics in the High Schools of the Future."

Discussion of the papers was led by Prof. Frederick R. Gorton of Michigan State Normal College and H. Clyde Krenerick of North Division High School, Milwaukee.

Mr. Gorton pointed out the contrast between the fine high school buildings of the cities and the high school buildings of the villages, and spoke of the excellence of the work done in the village schools. The difference in results achieved by city and village schools is small compared with the difference in equipment. He pointed out that most of the designs shown by Mr. Wilkins were for city schools, also that the interests of boys were better provided for than those of girls. There is need for a study of the country problem and for designs for country and village high school buildings. Textbooks have been written for the experienced teacher. There is need for a new type of textbook written for the inexperienced teacher. A revision of the physics course is needed. Applied physics should be presented in the laboratory. The laboratory of the future will take on more the appearance of a shop or a kitchen.

Mr. Krenerick made a plea for a study by the section of the content and distribution of the subject matter of the physics course. He recommended the substitution of general science for physics, saying that the general science idea might be extended to the later years of the course, that we might have science 1, science 2, and so forth, as we have English 1,

English 2, and so forth. He objected to the teaching of the metric system in the physics course on the ground that it means a loss of time. He said that English units only should be used, unless the metric system is taught in the mathematics course.

W. R. Ahrens, Englewood High School, Chicago, presented a new Boyle's law apparatus, in which oil is used instead of mercury.

A general discussion of the papers followed.

C. H. Smith, Hyde Park High School, Chicago, asked as to how we can apply the ideas that have been set forth. He stated he would like to receive ideas for publication in *SCHOOL SCIENCE AND MATHEMATICS*. This magazine is aiming to bring the university man and the high school man closer together. A recent innovation with this end in view is the department devoted to research. Mr. Smith then called upon Prof. Dodge of the University of Iowa, who has charge of this department in the magazine, to speak.

Prof. Dodge said that he would like suggestions from readers of the magazine in regard to the new department. The object of this department is to interpret the results of research in such a form that they may be made use of in the classroom. It is hoped that the research department will bring to the teachers the results of research that are of interest to them, and that it will enable them to anticipate changes in treatment of subject matter in the textbooks. He referred to the new discoveries in regard to the nature of white light, which contradict the view set forth in the textbooks. Questions are constantly arising in the classroom which the teacher should be able to answer. The new department is intended to help him to answer them.

Prof. Dayton C. Miller, Case School of Applied Science, said that the metric system should be taught in the physics course. The metric system would now be adopted by the United States Government if the metric bill had not been lobbied against by the manufacturers.

C. E. Linebarger, Lake View High School, Chicago, said that pupils easily comprehend graphical and algebraic methods, but are unable to express their results in good English. He facetiously suggested that the laws of physics should be put in rhyme and set to music, and gave as an illustration a rendering of Boyle's law in rhyme of his own composition. This literary gem the Secretary was unable to secure for publication.

Prof. Barber, Illinois State Normal School, said that the U. S. Bureau of Standards is willing to assist in promoting the metric system, and stated that the cost of teaching the double system is five million dollars annually.

Mr. Barges, McKinley High School, said that teachers should not idealize their teaching too much. There is often a great contrast between the ideals set forth by a teacher in an address before such a meeting as this and his actual work in the classroom.

Mr. Hobbs, American School of Correspondence, who is related to S. W. Stratton, head of the U. S. Bureau of Standards, spoke of Mr. Stratton's struggle to get the metric bill through. It is a matter of educating Congress. It is inertia, not antipathy, that prevents the passage of the bill.

Prof. R. A. Millikan, University of Chicago, pointed out that a reshaping of the content of the curriculum must be done, and is being done, but not by physics men. There are two possibilities—one is to hash all the sciences and teach them together as science; the other is to teach separated sciences. We cannot do both. General science in the first year means cutting out one of the special sciences. The report of the commit-

tee bears this out. The convincing point in Prof. Stewart's address was his urging the reconstruction of the science courses by science men. In reply to a question by Mr. Hawthorne, Crane Technical High School, Chicago, Prof. Millikan said that he objects to scrambling the sciences in the first year and unscrambling them in later years. The two systems do not fit.

C. E. Spicer, Joliet High School, said he hoped the Association would stand for first-year general science in order that we might influence the men who make the courses to give us more science in the high school. He thought that instead of dividing on the question of general science or separate sciences, we should unite in order to get more science in the course.

It was moved by Mr. Hawthorne that the Chair appoint a committee to prepare a three-year course in science to be submitted to the Association. E. E. Burns moved to amend by substituting for the original motion a motion that the Chairman appoint a committee of three to consider the content and distribution of the science courses in the high school and report what action should be taken, this committee to cooperate with corresponding committees from other sections.

The amendment was carried, and the motion as amended was carried.

A Nominating Committee was appointed by the Chair as follows: Frank E. Goodell, Chairman, University of Iowa, Iowa City, Iowa; Arthur W. Zehetner, Dubuque, Iowa; Ira D. Yaggy, Joliet, Ill. The committee made the following nominations, and the persons nominated were elected:

Chairman—Charles E. Albright, North High School, Columbus, Ohio.

Vice-Chairman—T. R. Wilkins, University High School, University of Chicago.

Secretary—Guy E. Foster, South High School, Youngstown, Ohio.

A Committee on Resolutions was appointed by the Chair as follows: Frederick R. Gorton, Chairman, Michigan State Normal College, Ypsilanti, Mich.; T. L. Harley, Hyde Park High School, Chicago; Allan Peterson, East High School, Des Moines, Iowa.

The committee presented the following resolutions, which were adopted by the section:

"Whereas, The Physics Section of the Central Association of Science and Mathematics Teachers has appointed a committee of three to investigate the content and distribution of the subject matter of physics in the high school science course, be it

"Resolved, That the Physics Section favor the appointment of a committee by the General Association which shall be representative of the several sciences concerned in such a science course, for the purpose of working toward a joint recommendation for a common end. Be it further

"Resolved, That the Physics Section favor the appointment of a committee to standardize plans for the laboratories of high schools which shall be adapted (a) to the village, (b) to the small city, (c) to the large city, and (d) to the technical school, with the recommendation that such plans be submitted to the U. S. Government for publication."

There was no meeting of the section on Saturday, the section having accepted the invitation of the American Physical Society to be present at its Saturday session.

E. E. BURNS,
Secretary pro tem.

ARTICLES IN CURRENT PERIODICALS.

American Forestry, for January; Washington, D. C.; \$3.00 per year, 25 cents a copy: "The Willows" (illustrated), Samuel B. Detwiler; "Bringing Back the Game" (illustrated), A. A. Allen; "The American Milkweeds" (illustrated), Dr. R. W. Shufeldt; "The Fundamentals of a Good Hedge" (illustrated), J. J. Levison; "The Fight Against the Pine Blister Disease."

American Mathematical Monthly, for January; 5548 Kenwood Ave., Chicago; \$3.00 per year: "The Logical Skeleton of Elementary Mechanics," E. V. Huntington; "Simple Hints on Plotting Graphs in Analytic Geometry," Aubrey Kempner; "A Course in Geometry for College Juniors and Seniors," J. N. Van der Vries.

American Naturalist, for January; Garrison, N. Y.; \$4.00 per year, 40 cents a copy: "The Personality, Heredity, and Work of Charles Otis Whitman," Dr. Charles B. Davenport; "Mendelian Factor Differences versus Reaction System Contrasts in Heredity," T. H. Goodspeed and R. E. Clausen; "Comparative Resistance of Prunus to Crown Gall," Prof. Clayton O. Smith.

Journal of Geography, for February; Madison, Wis.; \$1.00 per year, 15 cents a copy: "Minimum Essentials in Elementary Geography," Bessie P. Knight; "The Wood Pulp Industry," C. T. Anderson; "An Instance of the Changing Value of Geographical Location," John L. Rich; "Duluth, a Product of the Waterways," Eugene Van Cleef; "Aims in Geography Teaching;" "Indianapolis Plan for the Study of Africa;" "Current Material for the Geography Teacher."

Literary Digest; New York City. For January 20: "Why We Eat;" "Rhythmless Animals;" "Why Russian Shrapnel Is Polished;" "To Save the Horseshoe Fall;" "The Future of Alcohol;" "Is Railway Building to be Revived?" For January 27: "Peace Orders We May Get;" "Painless Photography;" "Is Stammering Hereditary?" "To Prolong Policyholders' Lives;" "Harnessing a Volcano;" "A Lighting Plant on the Car Axle."

Nature-Study Review, for January; Ithaca, N. Y.; \$1.00 per year, 15 cents a copy: "Nature-Study in Milwaukee," Florence J. Kane; "Botanizing in the Fall and Winter Months," Dr. R. W. Shufeldt; "Leaves from a January Notebook;" "The Diplomacy of the Good Teacher," John Walton Spencer; "The Old Pine Tree's Story," Anna Botsford Comstock; "The Lombardy Poplar," Margery B. Loughran; "January Nature-Study," Anna Botsford Comstock.

Photo-Era, for February; Boston, Mass.; \$1.50 per year, 15 cents a copy: "Nature-Studies With a Camera," William S. Davis; "Stormy-Weather Photography," Charles S. Oleott; "Better Bromides by Redevelopment," David Ireland; "Little Things That Matter," C. U. C.; "Work With Half the Lens," James W. F. Gregory; "The Use of Old Plates," R. Child Bayley; "A Camera Trip to the Blue Ridge Mountains," S. A. Weakley.

Physical Review, for January; Ithaca, N. Y.; \$6.00 per year, 60 cents a copy: "Light Produced by the Recombination of Ions," C. D. Child; "Counter Electromotive Force in the Aluminum Rectifier," Albert Lewis Fitch; "The Intensity of X-Ray Reflection, and the Distribution of the Electrons in Atoms," Arthur H. Compton; "An Effect of Light upon the Contact Potential of Selenium and Cuprous Oxide," E. H. Kennard and E. O. Dieterich; "Wave-Length Energy Distribution in the Continuous X-Ray Spectrum," Bergen Davis; "Temperature Coefficient of Contact Potential. A Rejoinder," K. T. Compton; "Note on the Determination by Judgment of the Constants of Linear Empirical Formulas," Harry M. Roeser.

Popular Astronomy, for February; Northfield, Minn.: "The Star Cluster M 13 in Hercules" (frontispiece); "The Sixty Finest Objects in the Sky," William H. Pickering; "A Few Pre-Copernican Astronomers," Edith R. Wilson; "An Investigation into the Increase of Star Density as the Milky Way Is Approached," Hector Macpherson; "Nineteenth Meeting of the American Astronomical Society (Concluded)."

Popular Science Monthly, for February; New York City: "Growing

Chrysanthemums;" "Shipping Day-Old Chicks Is Profitable at Both Ends;" "Growing Potatoes on the Roots of a Tomato Plant;" "Taking Care of Honey Bees During the Winter;" "Comfortable Cork Brick Flooring for Cattle;" "A Peculiar Disease of the Teeth;" "The Lesson Denmark Taught with Calves;" "How Much Ought We to Weigh Normally?"; "Is Space Itself Luminous?"

Review of Reviews, for January; *New York City*: "Peace, Politics, War—A Marvelous Month," Frank H. Simonds; "Francis Joseph and His Reign," Elbert Francis Baldwin; "Austria Faces the Future," T. Lothrop Stoddard; "German Military Leaders;" "Labor's Seven-Billion-Dollar 'Raise,'" J. George Frederick; "High Food Prices and Their Causes," David Shelton Kennedy; "The Wyoming Plan of Military Training," E. A. Walker; "Infantile Paralysis: What Have We Learned?"

School Review, for January; *University of Chicago Press, Chicago*; \$1.50 per year, 20 cents a copy: "The High School of Tomorrow," David Snedden; "The Arlington Plan of Grouping Pupils According to Ability in the Arlington High School, Arlington, Mass.," Frederick E. Clerk.

School World, for January; *Macmillan & Co., London, Eng.*; 7s 6d per year: "School Gardens in Ireland," L. J. Humphrey; "A Program of Education Reform;" "Educational Progress in New Zealand," J. A. Hanan.

A MERITED PROMOTION.

Dr. Otis W. Caldwell, of the University of Chicago, has recently been appointed Director of the experimental school which will be established by Teachers College, Columbia University, and supported by the General Education Board. This school has been designed for the purpose of an experiment in the reorganization of the curriculum of the elementary and secondary school. It is proposed to determine whether better educative results may be secured through training by use of materials related more closely to the work and interests which occupy the time and attention of persons in their regular occupations. The school will be equipped with the very best facilities and teachers obtainable, so that the experiment may be carried out under favorable conditions. It is expected that any good results that come from the experiment will be made available to schools generally, but it is clearly understood that public schools will make use of any results from this school, only as there is clear and practicable demonstration under normal school conditions. It is planned to include in the course an increased amount of practical science, household and industrial arts, and modern languages—English, French, German, Spanish, Italian; to include more social and industrial history, music, art and literature. The experiment will include not only a change in the nature of the materials of the curriculum, but also in the method of work, since constant effort will be made to recognize the interests and needs of individual education.

The Administrative Board of the new school includes the Dean of Teachers College, Dr. J. E. Russell, who is the Chairman; the Director of the school, Dr. Otis W. Caldwell; also V. Everit Maey, Mrs. Willard D. Straight, Felix M. Warburg, Arthur Turnbull, Dr. George E. Vincent, Abraham Flexner, Dr. Wickliffe Rose, and Charles P. Howland.

The school is so organized as to secure the largest possible measure of cooperation with the different members of the faculty of Teachers College. The members of this faculty have been leaders in the scientific study of educational problems and of school surveys, and it is intended that the new school shall be used not only as a place of experiment, but that its results shall be carefully examined by those who are specialists in judging the relative values of different kinds of school work.

The Director of the new experimental school is an Indiana man by

birth, was graduated from Franklin College in 1894, and took the degree of doctor of philosophy in the University of Chicago in 1898. He has taught in district schools, city schools, high schools, and a state normal school. During the past ten years, Dr. Caldwell has been a member of the faculty of the University of Chicago, part of which time he has been Dean of University College. He is the author of numerous books and magazine articles dealing with science teaching. In the new position, as a member of the faculty of Teachers College, Dr. Caldwell will continue his work upon questions related to the use of science in public education.

Dr. Caldwell was for six years the Botany Editor of this Journal.

We are sorry to announce that the wife of our Mathematics Editor, Professor Herbert E. Cobb, passed away very suddenly on the afternoon of Wednesday, January 17. She was a very able and active woman, and will be greatly missed in the many activities and societies with which she was connected.

HERBERT F. FISK.

Death has claimed prof. Herbert F. Fisk, D.D., LL.D., the oldest of the Northwestern University professors. Dr. Fisk died at his home, Evanston, Ill., after a short illness and breaking down due to his age. For forty-three years he had been connected with Northwestern University. For the last thirteen years he had been Principal Emeritus of the Evanston Academy, the present academy building being named Fisk Hall in his honor. E. E. Olp now becomes President, as well as Manager, of the Fisk Teachers' Agency of Chicago (Incorporated).

DEATH OF PROF. F. E. L. BEAL.

Our present knowledge of the food habits of California birds is in a large measure due to the painstaking work of Foster Ellenborough Lascelles Beal, Assistant, United States Biological Survey, who for many years devoted considerable attention to the economic relations of the birds of this state. The extent and importance of this work are emphasized anew by the news of Prof. Beal's death, which took place at his home in Branchville, Md., on October 1, 1916, in his seventy-seventh year. J. S. Hunter, who worked with Mr. Beal in the Pajaro Valley when investigations were being conducted in California, pays this tribute to him: "He was a man who did not seem to grow old, took an interest in everything, was thoroughly energetic, and intensely interested in his work." With such characteristics, it is little wonder that the name of Foster E. L. Beal is revered wherever known, and that his publications are used as models by all younger workers.—[Condor.

BOOKS RECEIVED.

Food Study—A Textbook in Home Economics for High Schools, by Mabel T. Wellman, Indiana University. Pages xxi-324. 13.5x19 cm. Cloth. 1917. \$1.00. Little, Brown & Company, Boston.

An Elementary Course in Synthetic Projective Geometry, by Derrick N. Lehmer, University of California. Pages xiii-123. 13x19 cm. Cloth. 1917. \$0.96. Ginn & Company, Boston.

Problems in the Mathematical Theory of Investment, by Guy R. Clements, University of Wisconsin. Pages 27. xiii x 19 cm. Cloth. 1917. \$0.32. Ginn & Company, Boston.

Calculus, by Herman W. March and Henry Colff, University of

Wisconsin. Pages xiv-360. 13x19 cm. Cloth. \$2.00. McGraw-Hill Book Company, New York City.

Geography of the Upper Illinois Valley and History of Development, Bulletin No. 27, by Carl O. Sauer. 208 pages. 18x25.5 cm. Cloth. Illinois State Geological Survey, Springfield, Ill.

Transactions of the Illinois Academy of Science, Vol. 8, by A. R. Crook. Pages 159. 14x22 cm. Paper. Illinois Academy of Science, Springfield, Ill.

BOOK REVIEWS.

Plane and Spherical Trigonometry, by C. I. Palmer and C. W. Leigh, Associate Professors of Mathematics in the Armour Institute of Technology, Chicago. Pages xi+188+132. 16x23.5 cm. 1916. McGraw-Hill Book Company, Inc., N. Y.

To meet the demands of many schools and colleges, this new edition includes a short chapter on spherical trigonometry. A number of new exercises have been added to the plane trigonometry. The former edition proved to be a most satisfactory textbook since the definitions and proofs of theorems were presented in simple, straightforward fashion, and an abundance of good drill exercises was supplemented by a large number of excellent practical problems. The tables are printed in large clear type.

H. E. C.

Drill Book in Plane Geometry, by Robert Goff, Teacher of Mathematics in the B. M. C. Durfee High School, Fall River, Mass. Pages xii+113, 13x19 cm. 1916. The Riverside Press, Boston.

Since many teachers are still placing much emphasis on the disciplinary value of the subject, the author has planned a book to increase this emphasis—emphasis on analysis, classification, and method. The theorems are arranged according to their conclusions, rather than according to their conditions, and the principal theorems that prove any one thing, such as equality, are grouped in one chapter. No proofs are given; they are to be found in the class. The summaries of methods in each group, exercises applying to these summaries, comprehensive sets of review questions, and numerical and algebraical exercises, in addition to the construction of all proofs, furnish material for a year's work in this small volume.

H. E. C.

Algebra Review, by Charles H. Sampson, Head of Technical Department, Huntington School, Boston. Pages iv+41. 13x19 cm. 40 cents. 1916. World Book Company, Yonkers-on-Hudson, N. Y.

A systematic review of algebra in preparation for college entrance and other examinations is given in this book. All of the principal rules are given, all important proofs are referred to, and the actual proofs are called for. The problems, about two hundred in number, are arranged in groups of five. Each group is a day's lesson and relates to several different topics in order to keep up a general review.

H. E. C.

Number Stories, by Alhambra G. Deming, Principal of the Washington School, Winona, Minn. Pages 205. 14x19 cm. 60 cents. 1916. Beckley-Cardy Company, Chicago.

These stories are to be read to pupils in the intermediate grades. They furnish a drill in the essentials of arithmetic as applied to child experience; but it is the purpose to fix the attention of the pupils on the story and make the problem solving seem incidental. The numerous suggestions to the teacher will prove helpful. It seems as if this method of interesting children in the dry details of number work should be successful.

H. E. C.



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Agricultural Arithmetic, by W. T. Stratton, Assistant Professor of Mathematics, and B. L. Renick, Professor of Mathematics, Kansas State Agricultural College. Pages x+239. 13x19 cm. 50 cents. 1916. The Macmillan Company, New York.

The growing interest in agricultural courses in the high and elementary schools makes good textbooks in agricultural arithmetic a necessity. This book is well adapted to meet the requirements of advanced classes in elementary schools in the country and in high schools having agricultural courses. The fundamental principles of arithmetic are taught by using problems dealing with farm activities. The data of these problems are based on the most recent reports of various State Experiment Stations, and of the United States Department of Agriculture. Teachers interested in this work should examine this textbook. H. E. C.

The Supervision of Arithmetic, by W. A. Jessop, University of Iowa, and L. D. Coffman, University of Minnesota. Pages vii+225. 13x19 cm. \$1.10. 1916. The Macmillan Company, New York.

For a number of years the authors have been conducting surveys and investigations in which they have studied certain phases of the teaching and supervision of arithmetic. This book furnishes certain standards by which the supervisor of arithmetic may judge his course in that subject, and gives him tests for measuring the attainment of the pupils. Among the subjects considered are: subject matter of arithmetic, time allotment for arithmetic, dominance of methods in the teaching of arithmetic, grade for introduction of textbook, judging textbooks, algebra and geometry in grades, problems related to current business life, and tests

and results as shown by special investigations. Many tables and graphs give interesting and suggestive results of tests and investigations, which, with the discussions, make this a most desirable book for principals and supervisors.

H. E. C.

Elementary Algebra, Second-Year Course, by Florian Cajori, Colorado College, and Letitia R. Odell, North Side High School, Denver. Pages ix+197. 13x19 cm. 75 cents. 1916. The Macmillan Company, New York.

It is a pleasure to read this book and note the many separate particulars which betoken a good working knowledge of algebra gained by the pupil with less effort on the part of the teacher. Plenty of drill exercises, absence of complicated forms, large number of practical problems and practical application of graphs, logarithms before quadratics and radicals, the function concept presented as a fundamental idea in proportion, variation, and graphics, and connected with problems of everyday life, "division by zero impossible," and clearness of exposition are some of the distinctive features of this book.

H. E. C.

Introduction to Mathematics, by Robert L. Short, Principal of West Technical High School, Cleveland, Ohio, and William H. Elson, Former Superintendent of Schools, Cleveland, Ohio. Pages vii+200. 13x19 cm. \$1.00. 1916. D. C. Heath & Company, Boston.

It is difficult for most of us to give up the notion that algebra and geometry must be taught as sciences and isolated sciences at that, because they have been developed (adventitiously?) in that form. However, the belief is slowly growing that related portions of arithmetic, algebra, and geometry may be combined in a course that will give pupils a usable knowledge of mathematics and the ability to apply that knowledge in a practical way.

This volume of the *Junior High School Series* is a welcome addition to the list of textbooks that are bound to come into general use. In it a study of the numbers of arithmetic leads to algebraic number. The equation is introduced early and used continually, as the geometry demonstrations are largely in algebraic form. A large number of applied problems furnish practice in solving the problems that arise in the shops and in household arts. The work as planned for a year covers algebra through fractional equations and straight line geometry to proportion.

H. E. C.

Elementary Mechanics for Engineers, by Clifford N. Mills, Assistant Professor of Mathematics, South Dakota College of Agriculture and Mechanic Arts. Pages viii+127. 12x18 cm. 1916. D. Van Nostrand Company, New York.

A good working knowledge of kinematics, kinetics and statics is assured the student who works through the 336 problems in this book. These problems, largely original, are of a nature to develop interest in the subject and ability to handle such problems when they come up in engineering work. This course, covering a semester's work of three hours a week, assumes a knowledge of mathematics through trigonometry.

The explanations though brief are clear and easily grasped; and the discussions of principles furnish needed help at points of difficulty without enshrouding the subject in a fog of hairsplitting technicalities. The compact arrangement and form of the book make it an ideal pocket reference book. Attention is called to a typographical error on page 55. The line near the middle of the page should read, "Now, if the values of W , a , b , and c are known, and $a=b$, then."

H. E. C.

Second-Year Mathematics for Secondary Schools, by Ernst R. Breslich, Head of the Department of Mathematics in the University High

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School, University of Chicago. Pages xx+348. 14x20 cm. \$1.00 and postage. 1916. The University of Chicago Press.

The long list of schools that have used *First-Year Mathematics* in this series is satisfactory evidence of the awakened and sustained interest in combined mathematics. The completion of the second book in the series will lead to further adoptions. The development of arithmetic, algebra, geometry, and trigonometry side by side opens to the student a broad field of useful mathematics and lays the foundation for the successful solution of all kinds of problems. Of course, the combination must be made in a reasonable and judicious manner, and the long period of experimentation which gives rise to this series assures no hastily devised and untried scheme.

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H. E. C.

DIRECTORY OF SCIENCE AND MATHEMATICS SOCIETIES.

Under this heading are published in the March, June, and October issues of this journal the names and officers of such societies as furnish us this information. We ask members to keep us informed as to any change in the officary of their society. Names are dropped when they become a year old.

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(DEC. 28, 1917, TO JAN. 2, 1918.)

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- C.—*Chemistry*—WILLIAM ALBERT NOYES, University of Illinois, Urbana, Ill.
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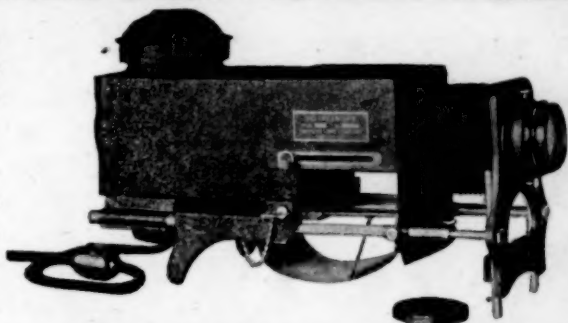
F. S. HAZARD, Office of the A. A. A. S., Smithsonian Institution, Washington, D. C.—117.

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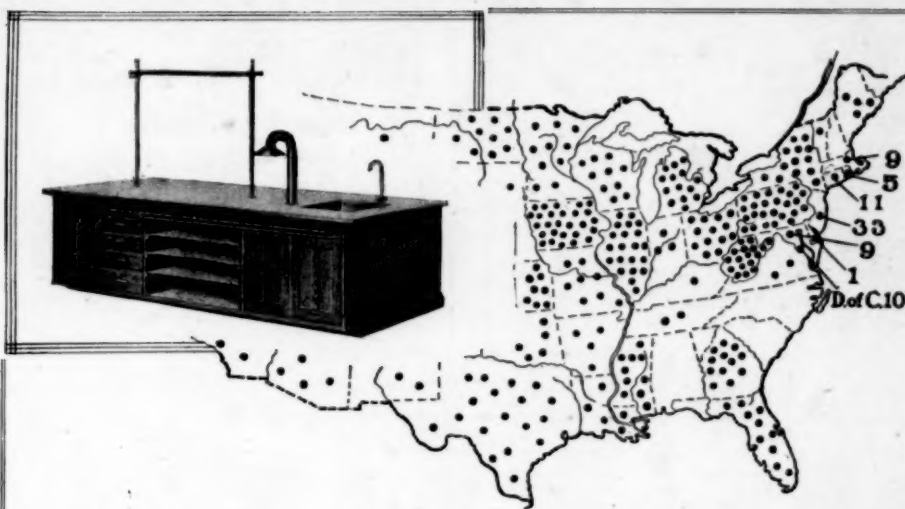
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